DOCUMENT RESUME

ED 058 396 VT 014 240

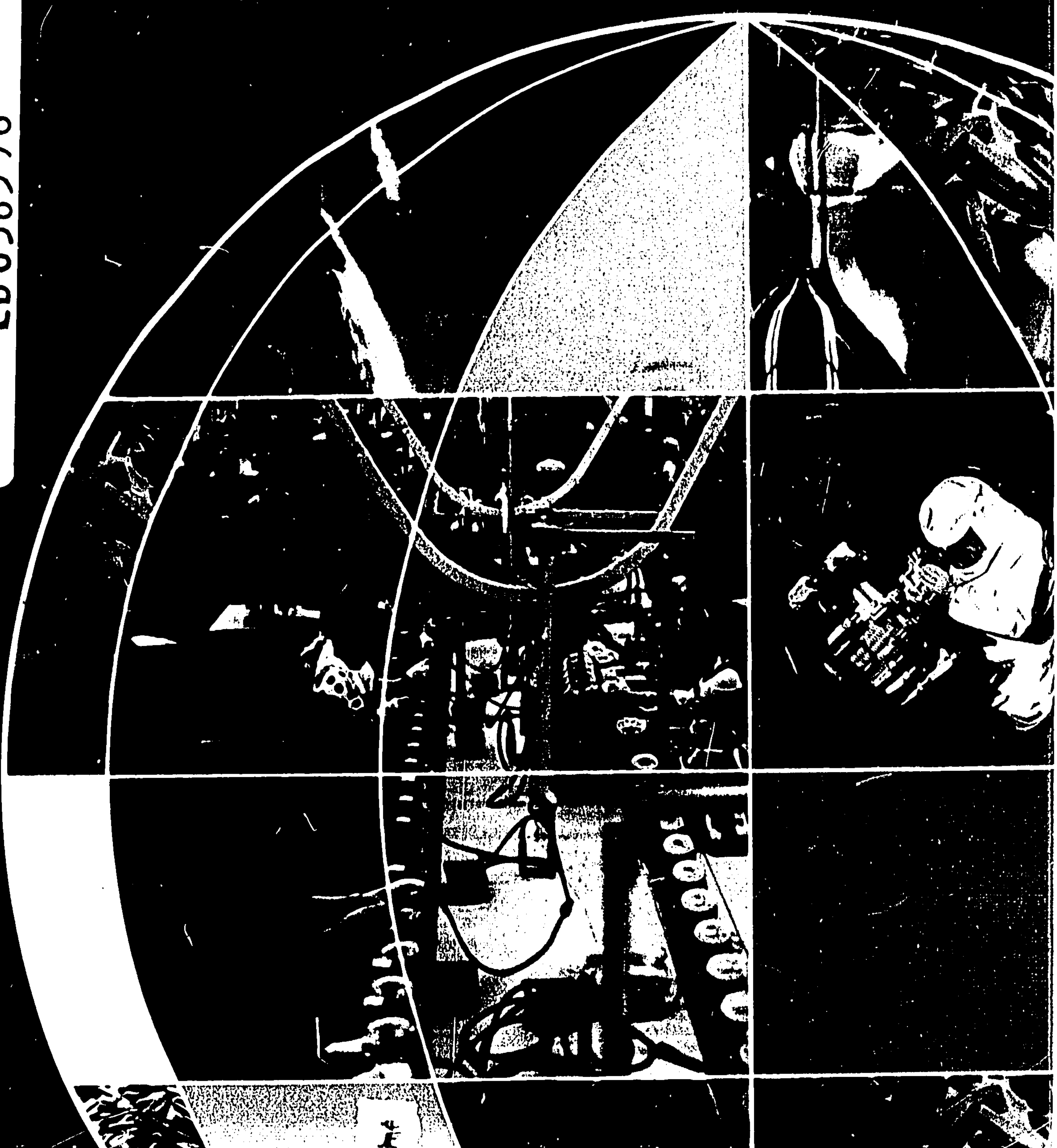
TITLE	The World of Manufacturing. Industrial Arts Curriculum Project.
INSTITUTION	Ohio State Univ., Columbus. Research Foundation.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C.
PUB DATE	71
NOTE	540p.; Fourth Edition
AVAILABLE FROM	McKnight and McKnight Pub. Co., Route 66, Bloomington, Ill. 61701 ($7.96 list price)
EDRS PRICE	MF-$0.65 HC Not Available from EDRS.
DESCRIPTORS	*Career Education; *Concept Teaching; Fundamental Concepts; *Industrial Arts; Industrial Technology; *Instructional Materials; Manufacturing Industry; Occupational Guidance; Occupational Information; Resource Materials; Secondary Grades; Study Guides; *Textbooks
IDENTIFIERS	IACP; Industrial Arts Curriculum Project; World of Manufacturing

ABSTRACT

This textbook for junior high school students encompasses concepts found in manufacturing, and together with a teacher's guide (VT 014 238) and laboratory manual (VT 014 239) constitutes the second part of a 2-year integrated program in industrial technology. This and the first year course in construction technology, were developed under contract to the U.S. Office of Education. The material was written by professionals in the manufacturing field, and is intended to give firsthand knowledge about the man-made world and enable students to view their world with greater understanding, appreciation, and insight. Sample topics included in the 82 are: (1) Manufacturing and the Economic System, (2) Building the Production Prototype, (3) Employment and Occupations in Manufacturing, (4) Converting Raw Materials to Industrial Materials, (5) Making Assemblies or Finished Parts, (6) Locating the Plant and Securing Inputs, and (7) Arranging for Distribution and Sales. There is extensive use of pictures and drawings for illustrations. Related documents are available as VT 014 088 and VT 014 241-VT 014 244. (GEB)

Industrial Arts Curriculum Project

THE WORLD OF Manufacturing



THE WORLD OF Manufacturing

DONALD G. LUX • WILLIS E. RAY, Co-Directors
Industrial Arts Curriculum Project
A. DEAN HAUENSTEIN, Assistant Director
Curriculum Development

McKNIGHT & McKNIGHT PUBLISHING COMPANY
Bloomington, Illinois

Fourth Edition

Lithographed in U.S.A.

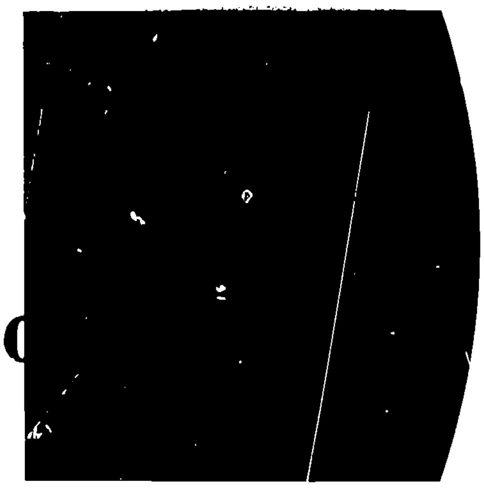
SBN: 87345-550-9

COVER DESIGN:

The editors wish to thank the following for their contributions to the cover design of THE WORLD OF MANUFACTURING:

- Gary Smith, Western Electric Company, Inc., New York, New York, and the Public Relations Staff at the Western Electric plant in Indianapolis, Indiana
- American Iron and Steel Institute, New York, New York (*Steelways*, March/April, 1970)
- Charles Pfizer & Company, New York, New York

Forew



The World of Manufacturing will provide an opportunity for you to become familiar with the man-made world around you — that part of the world produced by the manufacturing industry. Just how important manufacturing is can be observed by reflecting on what you need to live your life.

Nearly everything you do requires the use of a manufactured product. A baseball glove, bicycle, television set, pair of shoes, an automobile, and an ice cream cone all are there because there is a manufacturing industry. Imagine what your life would be like if you had to make all these things for yourself!

A study of *The World of Manufacturing* will help you understand what people who work in manufacturing do, because you will have firsthand experience in working with the knowledge and techniques which they use to earn their living. Even more importantly, this study will help you to better understand how you can affect and enjoy the industrialized society in which you live.

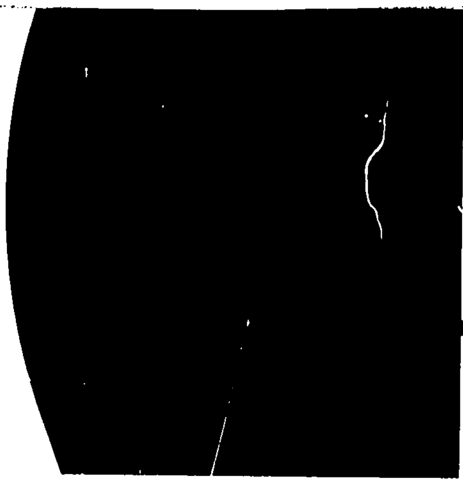
The first edition of this textbook was written in 1968; and, since then, many representatives of the manufacturing industry participated in revising and updating this material to its present form. You will find that the readings in this textbook "tell it like it is." The textbook ranges over the entire manufacturing industry.

Representing one of the major groups within the manufacturing industry, I recommend *The World of Manufacturing* as an important area of study. If you later join the industry as an engineer, technician, or production worker, you will want to know much about the team you are joining. Regardless of your career choice, the manufacturing industry is important to you.

Welcome to *The World of Manufacturing*.

R. Wm. Taylor

R. William Taylor
General Manager
Society of Manufacturing Engineers



eface

You are about to begin a new and exciting kind of education. You will gain firsthand knowledge about the man-made world in which you live. With this knowledge you will be able to view your world with greater understanding, appreciation, and insight. Until now few students have had a chance to study man's practices in manufacturing. To provide that opportunity, this educational program has been developed.

You will find the world of manufacturing so fascinating that you may want to make manufacturing your life's work. Even if your life's work is in some other field, you still need some basic knowledge about manufacturing. You and your family purchase many manufactured products. You need to make decisions about the nature of the products you buy. Whether or not society consumes satisfying and beautiful products, or frustrating and ugly ones, depends on people's knowledge of manufacturing.

This textbook was written by professionals in the manufacturing field, so you can be sure that what you read is accurate and up-to-date. The readings will help you form concepts or mental images of what the manufactured world is like. In the laboratory, working with a *laboratory manual* and tools and materials, you will solve realistic manufacturing problems that relate to the readings. In solving these problems, you will begin to understand some of the basic practices of modern manufacture.

The World of Manufacturing is a part of the answer to the growing demand for educational programs that deal with important industrial concepts. This program provides an excellent basis for advanced industrial studies and for future life in our society.

Dr. Donald G. Lux
Dr. Willis E. Ray
Co-Directors

Acknowledgm

The readings in this textbook have been developed using the following procedure: 1) the overall structure of the textbook was conceived with the assistance of specialists from the fields of management, design and engineering, production, personnel, and labor representing the manufacturing industry; 2) outlines for each textbook reading were developed by the Project staff; 3) persons from industry qualified on the subject of each reading were asked to prepare a manuscript of approximately 1500 words; and 4) the editorial staff of the Project edited these manuscripts for style and age-graded the materials.

INDUSTRIAL ARTS CURRICULUM PROJECT PERSONNEL

Co-Directors
Donald G. Lux
Willis E. Ray

Assistant Directors
James J. Buffer, Evaluation
A. Dean Hauenstein, Curriculum Development
Henry J. Sredl, University of Illinois Division

Advisory Committee

Max Beberman, Director (deceased)
Curriculum Laboratory
University of Illinois
Urbana, Illinois

Rupert N. Evans (Chairman)
Professor of Vocational and Technical Education
University of Illinois
Urbana, Illinois

John E. Harmon
Executive Vice President
National Employment Association
Washington, D. C.

Daniel MacMaster, President
Museum of Science and Industry
Chicago, Illinois

M. A. Maurer, Vice President
Northrop-Ventura
Newbury Park, California

C. I. Mehl
Assistant Executive Director
The Associated General Contractors of America
Washington, D. C.

M. Eugene Merchant
Director of Research Planning
Cincinnati Milacron Inc.
Cincinnati, Ohio

Nicholas J. Radell, Vice President
Cresap, McCormick, and Paget, Inc.
Management Consultants
Chicago, Illinois

Bernard M. Sallot
Assistant General Manager
Technical Divisions
Society of Manufacturing Engineers
Dearborn, Michigan

Jerome M. Shostak
Education Specialist
Western Electric Fund
New York, New York

William Sidell, First General Vice Pres.
United Brotherhood of Carpenters and Joiners of America, AFL-CIO
Washington, D. C.

Charles W. Staab
Former Executive Vice President and Business Manager
Cincinnati Enquirer
Cincinnati, Ohio

I.A.C.P. FIELD EVALUATION CENTER DIRECTORS AND TEACHERS

Center		*Personnel*
California Long Beach	* Glenn Warrick ° William Guidinger	Harry Crosby Edward Hambly Candelario Rodriguez
Florida Dade County	* James Morris ° James Fales	Stephen Baldwin Richard Baszczoski Raymond Klein
Illinois Chicago-Evanston	* Henry J. Sredl ° Anthony J. Simonaitis	James Kobus Dennis F. Partekel
New Jersey Trenton-Hamilton Township-New Brunswick	* J. Russell Kruppa ° Warden B. Muller	Wayne R. Donnelly Thomas U. Meirs Edward Mitchell
Ohio Cincinnati Columbus	* Jack Ford ° Everett Sheets	Charles Binstadt Larry Klasmeier Jerry Mitchell James Cameron
Texas Austin	* Donald L. Clark ° E. Perry Suter	Samuel Owens Gilbert M. Steelhammer Larry L. Stiggins

* Center Director
° Head Teacher

RESEARCH ASSISTANTS AND ASSOCIATES

Norman L. Asper
Richard V. Barella
Vern M. Bonar
Walter R. Bortz
Larry W. Browder
Roy A. Buckingham
John Butala, Jr.
Paul C. Caley
Marc A. Caron
Vincent C. D'Ambrosio
Donald R. Darrow
Ralph Dirksen
William E. Dugger
Glenn L. Ehlers
James N. Fancher
Phillip A. Fazzini
Bill J. Frye
Ronald L. Hoenes
Lawrence A. Inaba
Lewis D. Kieft
Donald W. Kinzy
Richard A. Kruppa
Paul D. Kuwik
Clair R. Lemasters
Larry R. Miller
Richard F. Peter
Arthur J. Rosser
Stanford D. Ruggles
Lyle R. Schroeder
James A. Schlottman
Lorin V. Waitkus
Floyd B. Walgren
Robert E. Weber
Robert E. Wenig
William E. West

WRITERS AND REVIEWERS

Wallace H. Appel
Industrial Design Manager
Westinghouse Electric Corporation
Columbus, Ohio

Thomas M. Barnes
Battelle Memorial Institute
Columbus, Ohio

John G. Berryman
School of Technology
Kansas State College of Pittsburg
Pittsburg, Kansas

Harry R. Blaine
Labor Education and Research Service
The Ohio State University
Columbus, Ohio

Peter L. Blake
Society of Manufacturing Engineers
Dearborn, Michigan

Francis W. Boulger
Senior Technical Advisor
Battelle Memorial Institute
Columbus, Ohio

George Bruggeneier
Firestone Tire and Rubber Company
Akron, Ohio

Charles F. Carter, Jr.
Director of Physical Research
Cincinnati Milacron Company
Cincinnati, Ohio

Lester V. Colwell
Department of Mechnical Engineering
University of Michigan
Ann Arbor, Michigan

Daniel J. Coogan, Jr.
Cresap, McCormick, & Paget, Inc.
Management Consultants
New York, New York

Walter S. Corvine
Director, Computer Centre
Chicago State College
Chicago, Illinois

Robert C. Crago
Owens-Illinois
Toledo, Ohio

Robert R. Dempsey
Director, Industrial Systems Laboratory
Syracuse University Research Corporation
Syracuse, New York

Donald C. Ebel
Cresap, McCormick, & Paget, Inc.
Management Consultants
New York, New York

Paul T. Eisele
Chief Engineer, Machine Tool Division
The Warner and Swazey Company
Cleveland, Ohio

Jay E. Endres
Manufacturing Manager, Machinery & Systems
Carrier Air Conditioning Company
Syracuse, New York

Robert Fair
Graduate School of Business Administration
University of Virginia
Charlottesville, Virginia

Leslie Fletcher
Society of Manufacturing Engincers
Dearborn, Michigan

Arnold Frey
Cleveland Foundry
The Ford Motor Company
Cleveland, Ohio

Rodney D. Gardner
Pan American Petroleum Corporation
Houston, Texas

Howard W. Geyer
Vice President, Manufacturing
The Warner and Swazey Company
Cleveland, Ohio

C. H. Goodyear
Manager of Manufacturing and Engineering Services
Western Electric Company, Inc.
Columbus, Ohio

Henry L. Grant
Technical Editor, Newsletters
Society of Manufacturing Engineers
Dearborn, Michigan

Jon P. Grove
Manager, Engineering Education
Society of Manufacturing Engineers
Dearborn, Michigan

Mrs. Adolf Haas
Worthington, Ohio

A. M. Hall
Battelle Memorial Institute
Columbus, Ohio

Paul Hammacher
Manager, Industrial Engineering
U.S. Plywood-Champion Papers Inc.
Hamilton, Ohio

Stanley T. Hardy
Academic Faculty of Management Science
The Ohio State University
Columbus, Ohio

J. H. Hurley
Vice President, Administration
The North American Coal Corporation
Cleveland, Ohio

International Association of Machinists and Aerospace Workers, AFL-CIO
Education Department
Washington, D. C.

George E. Jaeger
Personnel Division
Cincinnati Milacron Company
Cincinnati, Ohio

Robert Jones
Bureau of Employment Services
State of Ohio
Columbus, Ohio

Lawrence G. Kaseff
Ph.D. Student, Economics
The Ohio State University
Columbus, Ohio

Dianne Katzenmoyer
Bureau of Employment Services
State of Ohio
Columbus, Ohio

Donald R. Kibbey
Industrial Engineering Department
The Ohio State University
Columbus, Ohio

William C. Lamparter
Battelle Memorial Institute
Columbus, Ohio

Edward J. Loeffler
The Warner and Swazey Company
Cleveland, Ohio

G. Joseph Loughry
Training Supervisor
Pittsburgh Plate Glass Company
Barberton, Ohio

Joel H. Magisos
Center for Vocational and Technical Education
The Ohio State University
Columbus, Ohio

John Mandl
Director of Training
National Machine Tool Builders' Association
Washington, D. C.

George E. Mead
Personnel Development
Cincinnati Milacron Company
Cincinnati, Ohio

A. W. Meanor
Supervisor, Division of Safety
Industrial Commission, State of Ohio
Columbus, Ohio

M. Eugene Merchant
Director of Research Planning
Cincinnati Milacron Company
Cincinnati, Ohio

Geraldine E. Miller
Columbus, Ohio

Robert A. Miner
Manufacturing Consultant
IBM Corporation
Armonk, New York

Maurice Nelles
Graduate School of Business Administration
University of Virginia
Charlottesville, Virginia

John H. Nielsen
Staff Editor, Vectors Magazine
Society of Manufacturing Engineers
Detroit, Michigan

Stuart L. Nisbett
Professor (Retired)
General Motors Institute
Flint, Michigan

Ohio Manufacturers' Association
Staff Members
Columbus, Ohio

Phillip Patrick
Dayton Technical Institute
University of Dayton
Dayton, Ohio

Glenda Riley
Department of History
Denison University
Granville, Ohio

Arthur D. Roberts
Chairman, Tool and Manufacturing Engineering Technology
Norwalk State Technical College
Norwalk, Connecticut

David W. Roberts
Public Relations Department
The B. F. Goodrich Company
Akron, Ohio

Edmund Roberts
Superintendent, Manufacturing Planning
Westinghouse Defense and Space Center
Pompano Beach, Florida

Eleanore L. Rudolph
Computer Centre
Chicago State College
Chicago, Illinois

Charles J. Slanicka
Director, Labor Education and Research Service
The Ohio State University
Columbus, Ohio

Gary M. Smith
Public Relations Division
Western Electric Company, Inc.
New York, New York

George R. Snider, Jr.
Public Relations Department
The Procter and Gamble Company
Cincinnati, Ohio

Carl Snyder
Bureau of Employment Services
State of Ohio
Columbus, Ohio

John M. Stackhouse
Director, Department of Agriculture
State of Ohio
Columbus, Ohio

Donald V. Staudter
Dayton Technical Institute
University of Dayton
Dayton, Ohio

Paul D. Stein
Plant Manager
Thermo King Corporation
Minneapolis, Minnesota

R. P. Stock
Manager, Technical Service Department
The B. F. Goodrich Company
Akron, Ohio

August A. Tremer
Field Representative
United States Steel Corporation
Cleveland, Ohio

United Steelworkers of America, AFL-CIO
Education Department
Pittsburgh, Pennsylvania

Ivan R. Vernon
Staff Editor, Book Department
Society of Manufacturing Engineers
Dearborn, Michigan

Joseph Vinson
Ohio Petroleum Council
Columbus, Ohio

Richard E. Washam
Manager, Manufacturing Engineering
IBM Systems Manufacturing Division
Endicott, New York

Robert E. Willette
Manager, Technical Divisions
Society of Manufacturing Engineers
Dearborn, Michigan

W. P. Winter
Department of Industrial Engineering
The Pennsylvania State University
University Park, Pennsylvania

Many other individuals in manufacturing and related fields freely gave support, advice, and counsel to the Project staff. To these individuals, we also express our appreciation.

SOURCES OF ILLUSTRATIONS

AAA Plastic Equipment Company
Fort Worth, Texas
Addressograph-Multigraph Corporation
Cleveland, Ohio
Alcan Aluminum Corporation
Pittsburgh, Pennsylvania
Allied Chemical
New York, New York
Allis-Chalmers Manufacturing Company
Milwaukee, Wisconsin
Allyn & Bacon, Inc.
Chicago, Illinois
Aluminum Company of America
Pittsburgh, Pennsylvania
Aluminum Company of Canada
Montreal, Canada
American Brands, Incorporated
New York, New York
American Forest Institute
Washington, D. C.
American Foundrymen's Society
Des Plaines, Illinois
American Institute
of Timber Construction
Washington, D. C.
American Plywood Association
Tacoma, Washington
American Sheep Producers Council
American Society of Heating,
Refrigerating & Air-Conditioning
Engineers
New York, New York
American Telephone & Telegraph
Photo Service
New York, New York
American Textile Manufacturers
Charlotte, New Jersey
AMF Incorporated
New York, New York
Armco Steel Corporation
Middletown, Ohio
Armstrong Cork Company
Lancaster, Pennsylvania
Association of American Railroads
Washington, D. C.
Atomic Energy of Canada
Chalk River, Ontario, Canada
Atomics International
Division of North American
Rockwell Corporation
Canoga Park, California
Automobile Manufacturers Association
Detroit, Michigan
Babcock & Wilcox, Incorporated
New York, New York
Bell & Howell
Chicago, Illinois
Bell Telephone Laboratories
Murray Hill, New Jersey
Bendix Scully Jones Company
North Hollywood, California
Bethlehem Steel Corporation
Bethlehem, Pennsylvania
Black & Decker Company
Towson, Maryland

The Boeing Company
Seattle, Washington
Bostich, Incorporated
East Greenwich, Rhode Island
Brown & Root, Incorporated
Houston, Texas
Brown & Sharpe Manufacturing Company
North Kingston, Rhode Island
Bucyrus-Erie Company
South Milwaukee, Wisconsin
Butler Manufacturing Company
Kansas City, Missouri
Carrier Corporation
Cleveland, Ohio
Caterpillar Tractor Company
Peoria, Illinois
Center for Science & Industry
Columbus, Ohio
Cessna Aircraft Company
Bethpage, New York
Chicago Bridge & Iron Company
Oakbrook, Illinois
Chicago Wheel & Manufacturing Company
Chicago, Illinois
Chocolate Manufacturing Association
of the U.S.A.
Washington, D. C.
Chrysler Corporation
Detroit, Michigan
Cincinnati Milling Machine Company
Cincinnati, Ohio
Cities Service Company
Battle Creek, Michigan
Clark Equipment Company
Battlecreek, Michigan
Clausing Company
Kalamazoo, Michigan
Corning Glassworks
Corning, New York
Crouse-Hinds Company
Syracuse, New York
Cutler-Hammer, Incorporated
Milwaukee, Wisconsin
Di-Acro/Houdaille
Lake City, Minnesota
Dravo Corporation
Pittsburgh, Pennsylvania
DuPont Company
New York, New York
Eastman Kodak Company
Rochester, New York
Ebasco Services Incorporated
New York, New York
Ex-Cell-O Corporation
Detroit, Michigan
Fibre Box Association
Chicago, Illinois
First Federal Savings & Loan Company
Augusta, Georgia
Ford Motor Company
Dearborn, Michigan
Forging Industry Association
Cleveland, Ohio
Foxboro Company
Foxboro, Massachusetts

Freeport Sulphur Company
New York, New York
Fur Information & Fashion
Council, Incorporated
New York, New York
Furniture Design
& Manufacturing Magazine
Chicago, Illinois
General Dynamics
New York, New York
General Electric Company
Schenectady, New York
General Motors Corporation
Detroit, Michigan
Gisholt Machine Company
Madison, Wisconsin
Goodyear Tire & Rubber Company
Akron, Ohio
Great Western Sugar Company
Denver, Colorado
Hammermill Paper Company
Erie, Pennsylvania
Harsco Corporation
Long Island City, New York
J. Alvin Hawbaker, Realtor
State College, Pennsylvania
Hennage Lithograph Company
Hickok Electric Instrument Company
Cleveland, Ohio
Holcroft & Company
Livonia, Michigan
Humble Oil & Refining Company
Houston, Texas
Ideal Cement Corporation
Denver, Colorado
Illinois State University
Normal, Illinois
International Business Machines
Corporation
Armonk, New York
International Silver Company
Perth, Ontario, Canada
Jamestown Foundation
Williamsburg, Virginia
Jergens Tool Specialty Company
Cleveland, Ohio
Johns-Manville Corporation
New York, New York
Kaiser Jeep Corporation
Oakland, California
Kellogg Company
Battle Creek, Michigan
Kennametal, Incorporated
Latrobe, Pennsylvania
Kimberly-Clark Corporation
Neenah, Wisconsin
Libby, McNeil & Libby Incorporated
Chicago, Illinois
Libbey-Owens-Ford Company
Toledo, Ohio
Marble Institute of America,
Incorporated
Washington, D. C.
McIntosh Laboratory, Incorporated
Binghampton, New York
Arthur G. McKee & Company
Cleveland, Ohio
Merck & Company, Incorporated
Rahway, New Jersey

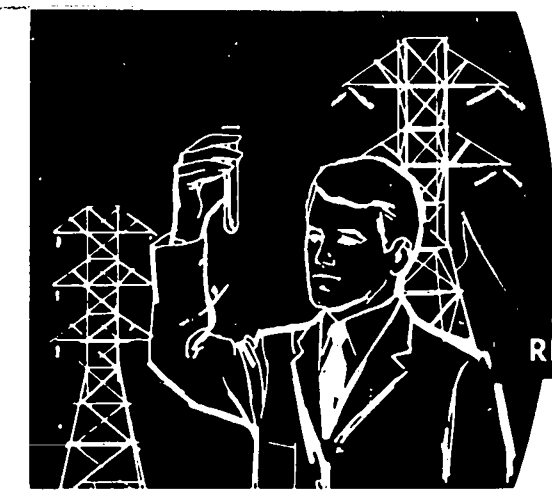
Millwood Sand Company
Zanesville, Ohio
Milwaukee Electric Tool Corporation
Brookfield, Wisconsin
Mobile Drillmaster Company,
Incorporated
Indianapolis, Indiana
Mobil Oil Corporation
New York, New York
National Coal Association
Washington, D. C.
National Confectioners Association
Chicago, Illinois
National Cotton Council
Memphis, Tennessee
National Dairy Council
Chicago, Illinois
National Lead Company
Albany, New York
National Machine Tool Builders'
Association
Washington, D. C.
National Water Well Association
Columbus, Ohio
Niagara Mohawk Power Corporation
Syracuse, New York
Northrop Corporation
Beverly Hills, California
Norton Company
Worcester, Massachusetts
Oberg Manufacturing Company
Freeport, Pennsylvania
The Ohio State University
Department of Photography
and Cinema
Columbus, Ohio
Old Sturbridge Village
Sturbridge, Massachusetts
Palmgren Steel Products
Division of Chicago Tool
& Engineering Company
Chicago, Illinois
Pan American Petroleum Corporation
New York, New York
Charles Pfizer & Company
New York, New York
Phillips Petroleum
Bartlesville, Oklahoma
Phil-Mar Corporation
Cleveland, Ohio
PhotoGraphics
Waukesha, Wisconsin
Portland Cement Association
Chicago, Illinois
Potash Company
Carlsbad, New Mexico
Pratt & Whitney Company
West Hartford, Connecticut
Prestressed Concrete Institute
Chicago, Illinois
Rex Chainbelt, Incorporated
Milwaukee, Wisconsin
Robbins & Myers, Incorporated
Memphis, Tennessee
Rockwell Manufacturing Company
Pittsburgh, Pennsylvania
Mr. Stan Ross
Downey, California

Shellfish Institute of North America
  Sayville, Long Island, New York
Shell Oil Company
  New York, New York
Sikorsky Aircraft
  Division of United Aircraft
    Corporation
  Stratford, Connecticut
Simpson Electric Company,
    Incorporated
  Chicago, Illinois
South Bend Lathe
  South Bend, Indiana
Sperry Rand Corporation
  New York, New York
Standard Oil Company
  Cleveland, Ohio
Syracuse China Company
  Syracuse, New York
3M Company
  St. Paul, Minnesota
Tinius Olsen Testing Machine
    Company, Incorporated
  Jenkintown, Pennsylvania
Unipunch Products, Incorporated
  Buffalo, New York
United Shoe Machinery Corporation
  Boston, Massachusetts
U.S. Army Corps of Engineers
  U.S. Department of Defense
  Washington, D. C.
U.S. Bureau of Commercial Fisheries
U.S. Department of Interior
  National Park Service
  Washington, D. C.
U.S. Industrial Chemicals Company
  New York, New York
U.S. Steel Corporation
  Cleveland, Ohio
Universal Engineering Company
  Division Houdaille Industries
    Incorporated
  Frankenmuth, Michigan
Vacu-Blast Corporation
  Belmont, California
Volkswagen of America
  Englewood Cliffs, New Jersey
R. D. Werner Company
  Greenville, Pennsylvania
Western Electric
  Columbus, Ohio
Westinghouse
  Columbus, Ohio
Weyerhauser Company
  Tacoma, Washington
W. A. Whitney Corporation
  Rockford, Illinois
Wirebound Box Manufacturing
    Association
Wyandotte Chemicals Corporation
  Wyandotte, Michigan
Zinc Institute, Incorporated
  New York, New York

Table of Conte

- 1 — Man and Technology
  - 2 — The Evolution of Manufacturing
  - 3 — Manufacturing and the Economic System
- 4 — Manufacturing Technology
  - 6 — Inputs to Manufacturing
  - 7 — Organization, Ownership, and Profit
    - 8 — Identifying Consumer Demands
    - 9 — Researching and Developing
    - 10 — Designing Manufactured Goods
      - 11 — Creating Alternate Design Solutions
      - 12 — Making Three-Dimensional Models
      - 13 — Refining the Design Solution
      - 14 — Obtaining Approval of Management
    - 15 — Engineering the Product
      - 16 — Designing Power Elements
      - 17 — Making Working Drawings
      - 18 — Building the Production Prototype
      - 19 — Technical Writing and Illustrating
    - 20 — Planning Production
      - 21 — Planning Processes
      - 22 — Automating Processes
      - 23 — Measuring Work
      - 24 — Estimating Cost
    - 25 — Tooling Up for Production
    - 26 — Installing Production Control Systems
    - 27 — Operating Quality Control Systems
    - 28 — Designing and Engineering the Plant
    - 30 — Supplying Equipment and Materials
    - 31 — Processing Data or Information
    - 32 — Using the Computer
  - 38 — Securing Reproducible Raw Materials
  - 39 — Extracting Raw Materials
  - 40 — Harnessing Energy from Nature
    - 42 — Converting Raw Materials to Industrial Materials
    - 43 — Making Industrial Materials into Standard Stock
    - 48 — Making Components or Finished Products
      - 49 — Material Forming Practices
        - 50 — Casting or Molding
        - 51 — Compressing or Stretching
        - 52 — Conditioning Material
      - 53 — Material Separating Practices
        - 54 — Shearing
        - 55 — Chip Removing
        - 56 — Separating by Other Processes
    - 57 — Making Assemblies or Finished Products
      - 58 — Combining Components
        - 59 — Mixing
        - 60 — Coating
        - 61 — Bonding
        - 62 — Mechanical Fastening
      - 63 — Combining Subassemblies
    - 64 — Preparing for Distribution
    - 65 — Servicing Manufactured Products
  - 29 — Establishing Accident Prevention Programs
  - 33 — Employment and Occupations in Manufacturing
  - 35 — Hiring and Training
  - 36 — Working, Advancing, and Retiring
  - 37 — Organized Labor and Collective Bargaining

Man and Technology



READING 1

Very little is known about how life began, but much is known about the ways in which the many kinds of living things have had to change in order to survive. The weather has always changed, and the surface of the earth has changed greatly many times. Plants and animals have had to *adapt* (change to meet new conditions) to these changes, and to others, or die out.

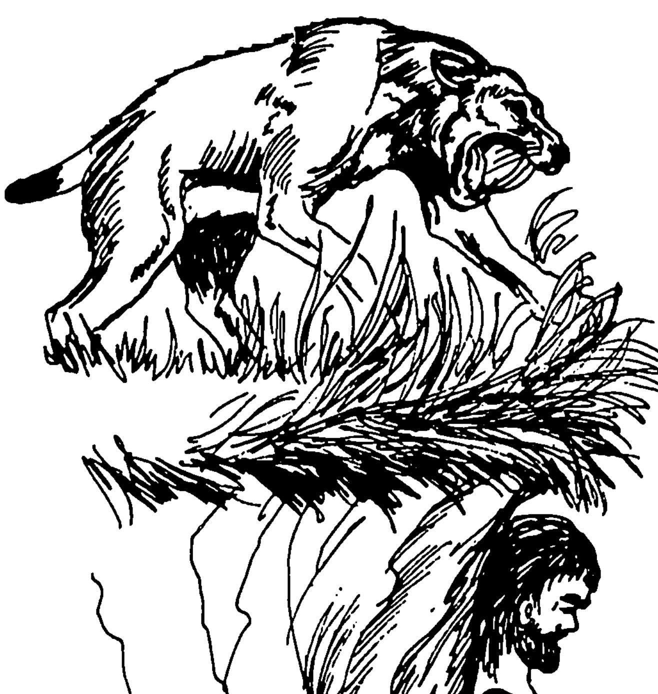


Fig. 1-1. Until he invented tools, primitive man had little control over his environment. His main odvantage was being oble to out-think the onimals around him.

Every kind of life that has survived has had some special *ability* that has helped it to survive. For man, one special quality has been his ability to *reason* (to think logically, to make judgments). Physically, man is no match for many kinds of animals, and he is not well protected by nature from the extreme changes in weather. But his ability to reason has led him to *invent* shelters, clothing, and other ways to protect and feed himself.

Man has another ability which has helped him survive. This is his ability to *speak*, to use *language*. By using language, man is able to express *ideas* and to make them known to his fellowman. In this way, individuals and groups of men are able to take advantage of new ideas and to profit by the successes and the mistakes of others.

Primitive Man and His Family

At first, man lived alone or in a small *family* group. His home was a cave or other natural shelter. His food was anything he could find from nature that was good to eat. When it was very cold, he could keep warm only by huddling next to others in his family. He had to depend on his *environment* (surroundings) without being able to change it very much. Figure 1-1 shows how this *primitive* (early) man may have looked.

The First Technology

Little by little, primitive man gained some control over his environment. Simple *tools* were the first things he invented to help him satisfy his need for food, clothing, and shel-

ter, and to protect him from everpresent dangers. By using tools, man was able to *extend* himself in his contact with the world of nature. Even the very simplest tools (like the piece of sharpened flint called the *hand ax* which was used for cutting and scraping or even digging up roots) were *extensions* of his hand, enabling him to change and control his surroundings.

Instead of killing animals with his bare hands, man started to use stones. With stone

Fig. 1-2. Tools gave man control over his environment. A hammer, axe, spear, bow and arrows, sling, or boomerang helped man protect himself and capture food. Other tools helped him to make clothing, start fires, and build shelters.

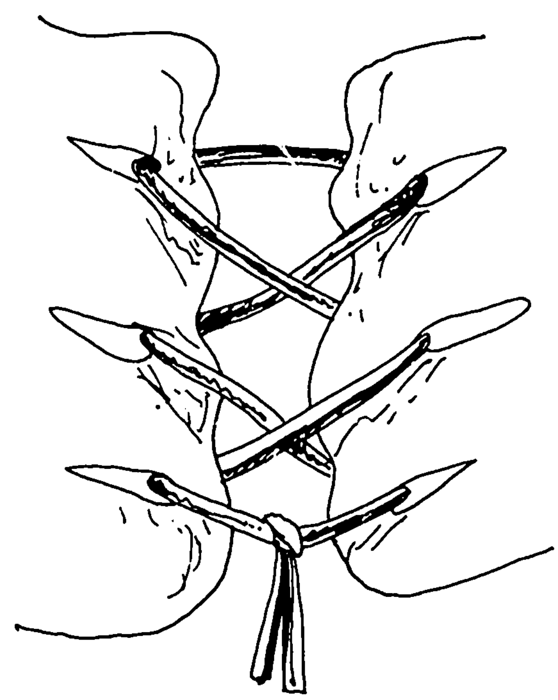


Fig. 1-3. Animal skins were the first material of nature that men learned how to use for clothing. The idea of lacing seems simple today, but it was an important step forward in the technology of making useful things.

Fig. 1-4. Learning how to start and control a fire enabled man to cook food and keep warm.

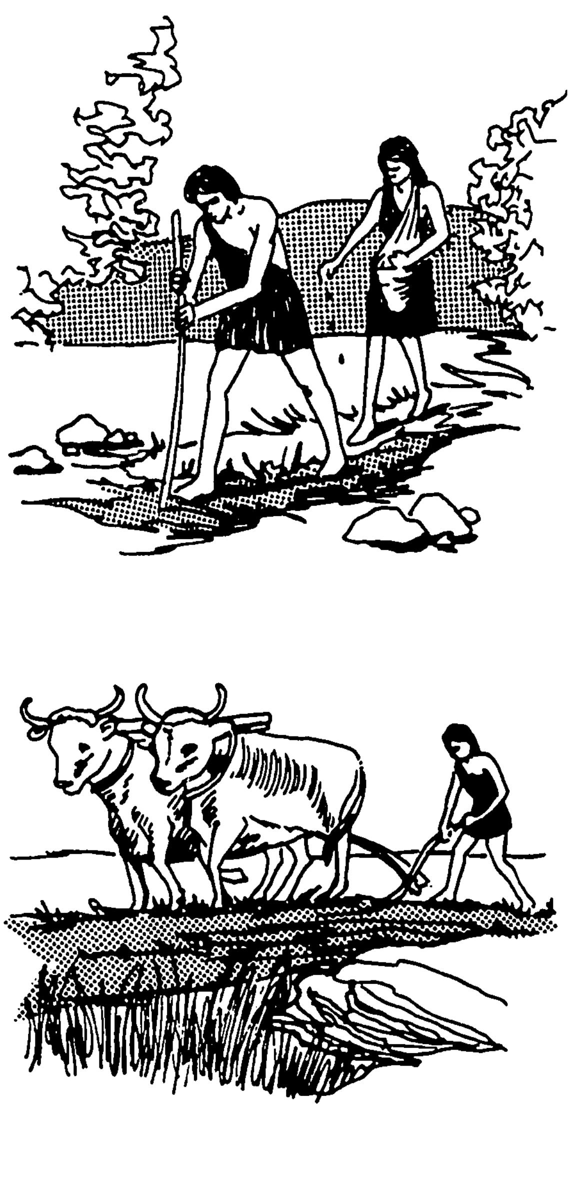


Fig. 1-5. When man learned how to plant and tend crops, he stopped wandering in search of food. With agriculture, he could settle in one place and build permanent shelters.

weapons he was more certain of eating every day. Later, he invented other ways to kill for food and to protect himself. Hammers, spears, slings, and the bow and arrow increased his ability as a hunter and made his life more secure, Fig. 1-2. He also shaped stones, antlers, and bones into knives and needles. He could then fasten together animal skins to protect him from the cold, Fig. 1-3.

In time, man invented *tools to make tools.* For example, a very hard stone tool could be used to shape a softer stone into a weapon or an instrument for cutting, scraping, or digging. Thus, his ability to extend himself grew even greater.

Eventually, man discovered how to start a fire, Fig. 1-4. He used fire to cook his food, to warm his cave, and to frighten away dangerous animals.

All of this knowledge was the beginning of *technology* (doing things in a skillful way). Man had begun to change his environment for his own comfort and protection. Today, we study *industrial technology* as the story of the many kinds of construction and manufacturing man has developed through the centuries and how this knowledge can be increased. But man's present knowledge of how to control his world could not have grown without the simple beginnings made by primitive man.

Agriculture

Man gained another and very important kind of control when he learned how to raise plants and animals. *Agriculture* (farming) probably was invented more than once, in different parts of the world, by primitive man. But it was mainly in the Middle East, in the valleys of the Nile and the Tigris and Euphrates Rivers, about 6500 B.C., that agriculture first became an important way of life. Agriculture gave man a new freedom. He no longer had to depend solely on hunting and the gathering of wild plants to supply his food each day, Fig. 1-5. Breaking the ground with a stick for seed planting

was replaced, in time, by the invention of the *plow* which could be pulled by *domesticated* (tamed) animals.

The *domestication* of goats, sheep, pigs, and cattle brought a greater supply of meat and other animal products. It is possible that the taming and breeding of animals took place even before the planting of grains. But these two things—(1) planting of crops and (2) breeding of animals—completely changed man's development.

Fig. 1-6. Basket weaving is a special skill that developed many thousands of years ago.

Fig. 1-7. The sled was a simple invention. It allowed man to take with him more than he could carry. The wheel was not invented until much later.

One important result of the invention of agriculture was the growth of more or less *permanent* (long-lasting) settlements or *communities* The growing of plant foods and the tending of flocks made it necessary for men to stay in one place in order to carry out these activities, at least most of the time. When the soil was *exhausted* (no longer able to grow crops), or there was a drought, then a *new settlement* would be located.

In permanent communities, the need for a *division of labor* (different kinds of work for different people) became necessary. New *regulations* (rules) had to be established so that all people of the community could work together smoothly for the *benefit* (advantage) of all.

Crafts

With more free time, man began to develop *crafts* (special skills).

1. He learned how to make clay containers to hold water.
2. He learned how to build sturdy shelters of clay, stone, or wood.
3. He devised ways of weaving pieces of vine and grass together to make baskets, Fig. 1-6.
4. Sleds helped him to carry his goods more easily and quickly than he could have carried them on his back, Fig. 1-7.
5. After a long time, he invented a loom for weaving fiber into cloth.

All these inventions and others helped man to move about and look for new homes. He was able to live in regions that were too cold or too dangerous for primitive man. Also, with more food many people could live as a group. In several parts of the world a *society* (a permanent group of people forming a single community) started to develop.

The Institutions of Society

Men first lived and worked together because they belonged to the same *family*. Many rules and *customs* (habits) grew up

around family life. In time, four other basic kinds of group activity developed: *religion, education, government*, and an *economic system* (ways of doing business). These five kinds of activity, including the family, are called the *institutions of society.*

Probably a simple form of each of these activities existed from the very earliest time in man's development, but after agriculture was invented each one grew in importance. Each one helped to spread ideas and to increase man's knowledge and control of his world. Let us look briefly at each of these institutions.

Fig. 1-8. Pictures on cave walls, drawn by men who lived long ago, have helped us learn about their lives. Very old tools, bones, shells, and the ashes of fires also give us some knowledge about them.

Religion

Religion is belief in a divine or superhuman power, or powers, to be obeyed and worshiped. It is also the expression of this belief in a *way of life*. Religion may have begun through man's sense of wonder about the world around him and through his questions about the unexplained events of nature. We do not know. Evidence of religious belief and practices has been found in the burial customs of very early man. Pictures and *symbols* (signs) found on cave walls show his need to express religious beliefs in pictorial form, perhaps also his need to gain the favor of the divine powers he worshiped, Fig. 1-8.

Religion for primitive man was principally a way to discover *meaning* in a world of unexplained happenings and mysterious events, not always from fear, but always in wonder. Religion has continued to be an important institution throughout history, especially when it has developed definite *codes of conduct* (rules for living) for its followers.

Education

Education is the process of rearing someone in the knowledge, skills, and attitudes needed to become a useful member of a family or community. Many kinds of animals learn by watching their parents and other animals. The children of primitive men learned in much the same way. Children today learn by *imitating* (copying) their parents. But, since man can teach by using *language* as well as by example, human beings can be taught *concepts* (ideas) by which they can understand and control the world around them.

The family was the first source of education for primitive man, and the family is still an important educational institution today. As knowledge grew over many centuries, however, learning in *schools* became an important way to keep a society permanent and well organized. Learning in schools also made progress possible because young people did not have to spend a lifetime learning from many mistakes in order to add to what their parents and teachers already knew.

Ownership and Government

Early groups of men followed leaders who were strong and clever. A leader made rules

and decided what was best for the group. The need for permanent laws grew slowly. When people of many families settled in one region to raise their own food crops, the idea of *ownership* (owning property) grew. Then it became necessary to have laws about land, crops, herds, and other kinds of property. Laws must be *enforced* (people must obey them) and they must be *interpreted* (explained) in certain cases. So, in a simple way at first, *government* grew up to protect the rights of individuals and of the whole community.

An Economic System Develops

As men settled and began to live in groups, they started *exchanging* (trading) goods. When groups were small, *barter* (swapping) worked well. As they grew and men began to travel, their lives became more *complex* (complicated). They needed a way of trading goods for something small and easy to carry, something everyone could take or give in trade. Then *money* came into use.

With money that everyone was willing to use, men grew to depend more on each other. Some men *specialized* (worked at one craft especially) in making pottery. Other men made cheese or wove blankets. Specializing led to a higher standard of living because it produced more and better goods and services.

Industry Today

You have learned that the economic system provides modern man with most of his goods and services. Goods are material objects. Services are work performed to improve material goods or to benefit people. Goods can be gotten by: (1) *extraction* and (2) *reproduction*. They can be processed by: (1) *construction*, and (2) *manufacture*. Of these four, construction and manufacturing (industry) change the shape, form, or size of materials the most.

An *art* is usually defined as an ability or skill to do certain things. When you put "industry" together with "arts", *industrial arts can be defined as the study of the use of tools and techniques to construct and manufacture goods and to service these goods.* This year, you will study the technology of manufacturing.

Summary

Primitive man had two important abilities to help him survive. He could reason and he could use language. At first, he could control

Fig. 1-9. Knowing how to make and use tools is now part of the branch of knowledge we call *technology*. It took thousands of years for man to develop technology from the primitive state shown.

his environment only slightly. Then he began to invent tools. This was the beginning of technology. Figure 1-9 shows a simple kind of agriculture, one important way that man learned to control his environment.

Later, man began to specialize. Each man did some things for himself and for others. This led to trade and the growth of an economic system and, eventually, to the use of money, Fig. 1-10.

Fig. 1-10. Before he devised money, man sometimes traded one kind of goods for another. This system is called *bartering*.

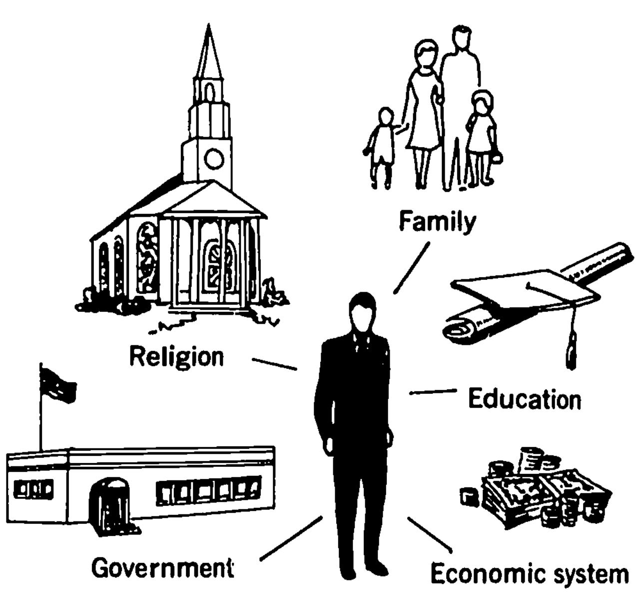
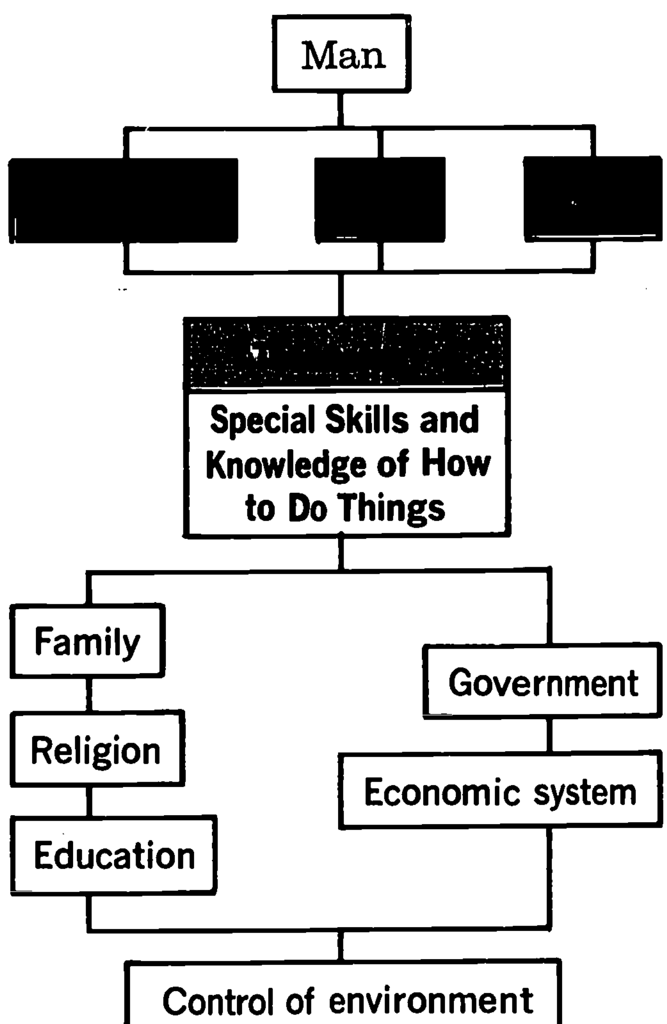


Fig. 1-11. Institutions of society.

As more and more men came to live together, they found that some form of government was needed. As living became more complex, formal education in schools also was needed. Man was curious about the world around him. Religions helped explain what he did not understand and gave him rules of individual and social conduct.

Through the ages man has worked out five main kinds of group activity: (1) family, (2) religion, (3) education, (4) government, and (5) an economic system. These activities, and the rules they follow, are called institutions of society, Fig. 1-11.

The economic system *provides* man with goods and services. Industry (construction and manufacturing) is one part of the economic system. This year you will study the technology of the manufacturing part of industry.



Terms to Know

adapt
ability
reason
invent
speak
language
ideas
family
environment
primitive
tools
extend
hand ax
extensions
weapons
society
customs
religion
education
government
economic system
institutions of society
way of life
symbols
meaning
codes of conduct
imitating
concepts
schools
ownership
tools to make tools
technology
industrial technology
agriculture
plow
domesticated
domestication
permanent
communities
exhausted
division of labor
regulations
benefit
crafts
enforced
interpreted
exchanging
barter
complex
money
specialized
extraction
reproduction
construction
manufacture
art
industrial arts
provides

Think About It!

1. Describe some ways in which people in your community buy goods and services *from* other people and in turn sell goods and services *to* them.
2. Name some of the advantages that come from a division of labor (specializing) in your own community.
3. How do you suppose primitive man discovered how to make a fire and how to control it?

The Evolution of Manufacturing

READING 2

Industry is the making of products by constructing and manufacturing. *Constructing* is the making of fixed products on a site. *Manufacturing* is the making of movable products which often are used some distance from where they are manufactured. Together, construction and manufacture provide modern man's food, clothing, and shelter. They extend his ability to travel and to speak or communicate. Manufacturing is the subject of this textbook.

Primitive Manufacturing

Early man chipped pieces of stone into weapons to defend himself and to hunt animals for food. He learned that he could use animal skins for clothing. He then began to weave dried grasses, twigs, and leaves into baskets, and to *shape* (form) clay and mud into pots.

Although man provided himself with many simple conveniences, it took a very long time to produce just enough for his own family. There was no money to exchange for goods and no way to move goods from place to place. Sometimes man did exchange or *barter* (swap) his goods for other products, but for thousands of years most men produced only enough for their own families' use. This system of production is called the *household system.*

As men grew more skillful in making and using simple tools, they explored more of the earth. Groups of people scattered across the lands we now call Africa, Asia, and Europe. Later they reached the Americas and Australia. Each group of people made things from the *materials of nature* that were easy to get. For example, Eskimos built small boats covered with animal skins, Fig. 2-1. Indians of the North American forests built birchbark canoes. In other lands, people built boats from reeds or hollow logs.

In different lands people invented more than one way to make the same kinds of things. Where there was clay, people shaped it into pots and dishes. In some places man found *metal ores* and discovered that they could hammer the metal into different shapes. Using wool from sheep, goats, llamas, or camels, they *devised* (invented) ways to spin yarn and weave cloth. They devised various kinds of containers to hold water or oil. They made ornaments to wear, like beads, rings, or headbands. They drew pictures and carved figures. They built rafts or boats and made all sorts of sails, oars, and towropes for moving them.

Many ideas were probably used more than once. For instance, who first thought of holding together two pieces of animal skin by lacing a leather strip through small holes? Did this idea spread as man traveled? Was

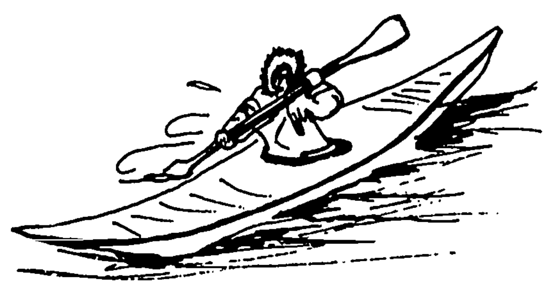


Fig. 2-1. The Eskimos used bone or driftwood to build frames for their kayaks. Many seals lived in their cold northern land, so they covered the kayaks with sealskin. Now there are few seals, and men have found other materials for making boats.

it invented several times in several places? We do not know. Men used such ideas for thousands of years before they invented writing.

Many skills used to make one product were later used to make something quite different. For example, as men became skilled in *firing* (baking) pottery, they learned much about controlling heat. This knowledge was used later when they devised the skill called *smelting* (heating ores until the metal melts and runs together). All of these skills developed at different times and in different places.

Technology Grows with Farming

The people who continued to hunt and fish for food developed only a few *crafts* (special skills). But in warm regions, in the great river valleys, men became farmers as we have seen. With the growth of farming skills (agriculture), men had a greater food supply and some free time. The technology of many crafts *evolved* (developed gradually) in these farming communities. Ideas and practices spread gradually in all directions. In the six permanent societies shown in Fig. 2-2, men learned how to construct large palaces and temples. Practical ways to provide water and to move waste materials out of the communities were worked out. A system of *writing* evolved in most of these societies. As knowledge grew, there was more *specializing*. Some people made jewelry, fine cloth, or furniture for a palace; others manufactured more common things like water buckets, farm carts, or work clothes.

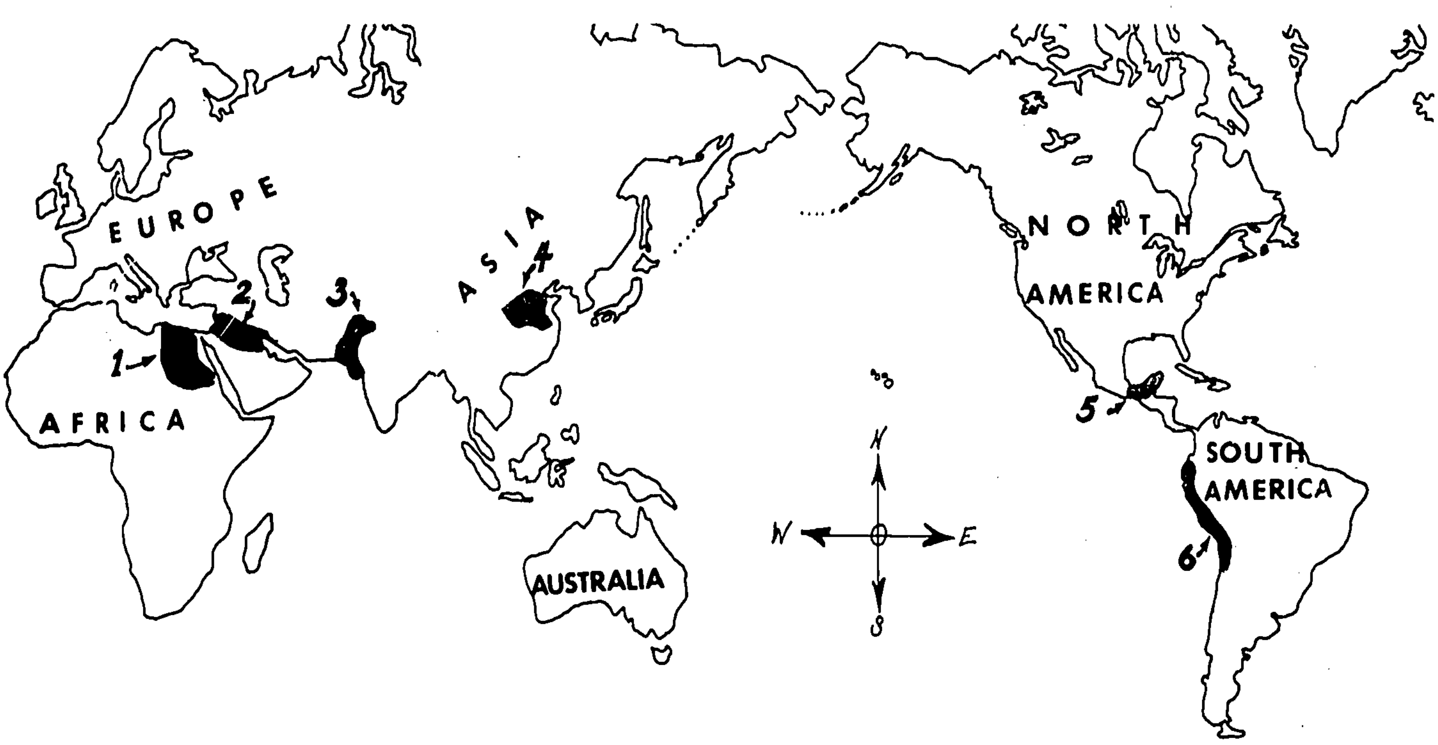


Fig. 2-2. Possibly men lived first in Africa. Slowly they moved east across the Europe-Asia land area. Later groups reached Australia and the Americas. Six permanent societies grew: 1—Egypt, 2—Mesopotamia, 3—India, 4—China, 5—Mexico, 6—Peru. Manufacturing skills and knowledge began chiefly in these societies. People settled also in many other places, but they did not develop the technology of making things to such a high level.

Technology Travels

Trading (buying and selling) was first practiced among people living in the same area. Later, men searched for products that they could not buy at home. They traveled farther. They brought back new kinds of *goods* (things that satisfy people's needs; wares) and also skills that were new to their society.

The technology that grew slowly in the farming societies of Africa and Asia for several thousand years, finally reached Europe. Ideas and inventions first moved along the waterways and later were carried by traders and by armies over the land routes. *Merchants* (buyers and sellers) from Greece began trading with Egypt (one of the earliest river valley societies). By 1500 B.C. this trade had become very important. Much of the Greek land had poor soil and was hilly and hard to farm. The people turned to *industry* and *trade*, especially sea trade, to support themselves.

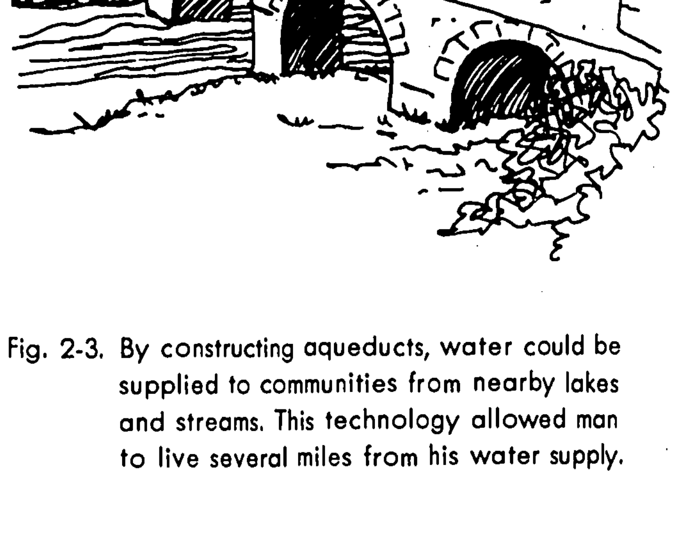


Fig. 2-3. By constructing aqueducts, water could be supplied to communities from nearby lakes and streams. This technology allowed man to live several miles from his water supply.

For more than 1000 years the Greeks improved technology. They improved the sailing ships first built by the Egyptians. They made better wheeled carts and horsedrawn chariots. They invented new uses for *smelted ores*. They carried the design and construction of public buildings to a high point of usefulness and beauty.

The Greeks also developed basic knowledge needed for trade and travel such as geometry and record-keeping. Their success in trade gave them time for literature, medicine, and the arts. Greek ideas and products were carried all over the known world.

When Greece was no longer able to solve its political problems, about 200 B.C., the country was taken over by the Romans who added to Greek ideas and inventions many of their own. They improved trade by building fast ships, good roads, and large bridges, thus shortening delivery time for manufactured products. They had the first *labor unions* (workers organized to protect their interests). They devised surgical instruments. They built a clever system of pipes to carry water long distances, Fig. 2-3.

By improved technology and by great success in the art of government, the Romans were able to spread the ideas and inventions of the Greeks, as well as their own, over a great part of the world. Even the old river valley societies of the Middle East became a part of the *Roman Empire*. Like the Greeks, however, the Romans finally were not able to solve their problems of government and were not able to control all the far-flung parts of their huge empire. Their empire fell and new groups of people took control of their lands.

The Middle Ages

The *Middle Ages* lasted from the fall of Rome (about 500 A.D.) to the 14th century. During this time a new society grew in Europe. People were busy settling new areas of land. They were collecting and storing the knowledge of many centuries from all parts

of the world, Fig. 2-4. Skilled craftsmen turned out many useful and beautiful products, Fig. 2-5, and *architects* (designers of buildings) and builders created great cathedrals, castles, and military structures. Instead of being years of darkness, the Middle Ages actually laid the foundations for the modern world.

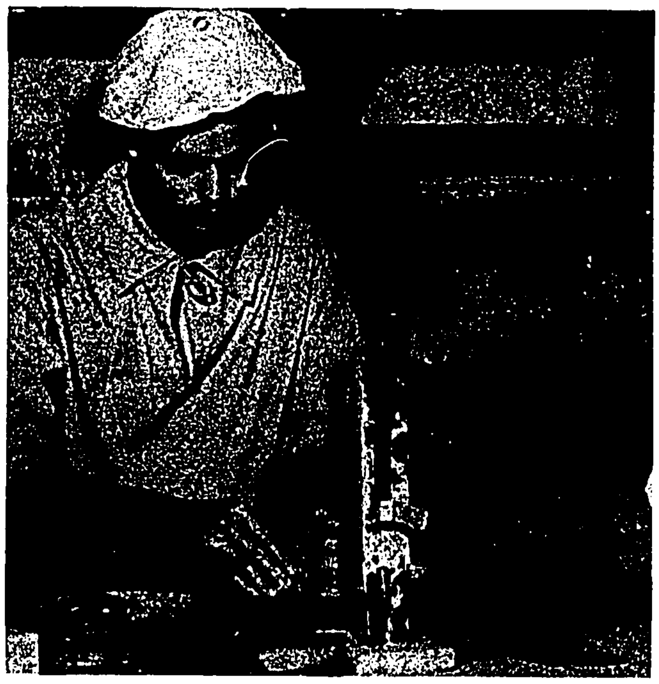


Fig. 2-5. During the Middle Ages, skilled craftsmen worked in their homes to produce the goods needed by society. They became very skillful in performing all of the steps required to turn out finished products.

The Renaissance

The *Renaissance* marked the beginning of the modern world. Starting in the 14th century, small groups of people discovered anew the ideas of Greece and Rome and used them in their own work. Other people began to study the world of nature with a new interest and curiosity. The Renaissance is often called the *Mercantile Period* because of the important part which merchants played in it. They helped to revive an interest in trade which in turn led to new developments in manufacturing.

Increased trade made people more interested in better products and more able to pay for them, so new industries sprang up. Fine

Fig. 2-4. With writing, knowledge could be recorded and stored. Scribes spent their lives hand-lettering the knowledge of the ages on parchment paper.

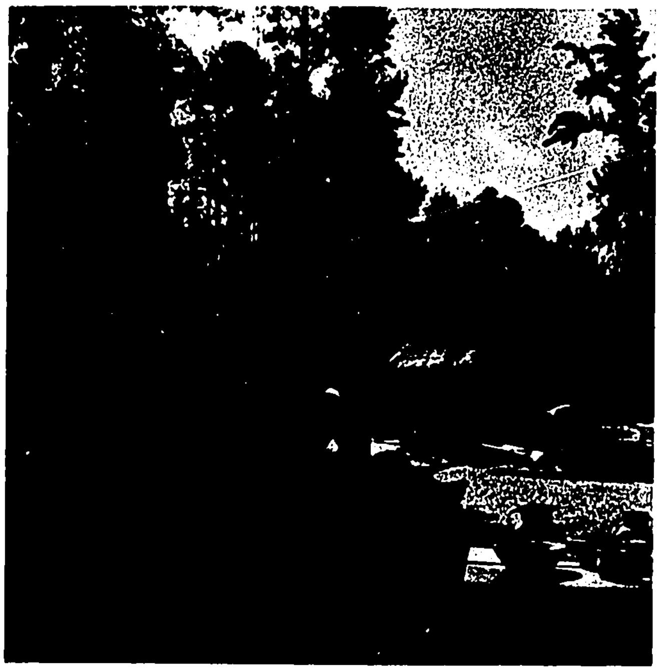


Fig. 2-6. During the Renaissance, many new crafts and skills developed. Usually the craftsman owned all his tools and did all the work in his own home.

cloth, silk and cotton goods, carved furniture, china, pewter, and silverware were very much in demand. These were produced by skilled craftsmen in small shops or by a worker in his own home, Fig. 2-6. In addition to new industries, there were also many discoveries and inventions. The spread of knowledge was increased by Gutenberg's invention of the movable type printing press in the 1400's, Fig. 2-7. Gunpowder, brought from China, led to the development of the cannon and other firearms. The magnetic compass and the sextant made navigation more accurate. Better smelting techniques for metals were developed. Copernicus discovered that the earth moved around the sun.

Many important voyages of exploration and discovery were made during this time. Setting out to discover new trade routes to the Orient, Columbus accidentally found America, an event that changed the course of history.

During the Renaissance, the arts separated even more widely from the crafts. Painting and sculpture were practiced for their beauty, not just to decorate a chest or a pot. People who were profiting from trade and industry bought these art objects to decorate their homes and to bring them pleasure. They also began to desire beautiful rugs for their floors, glass for their windows, and silks and perfumes for themselves. Improved manufacturing thus encouraged a more luxurious *standard of living.*

The Industrial Revolution

Three changes in manufacturing began toward the end of the 1700's. These were:

1. Making products with *machinery,*
2. Running the machinery with engines, and
3. Making the products in factories.

These changes are called *the Industrial Revolution.* It started in Great Britain and the countries of western Europe.

The first changes were in the spinning of thread and weaving of cloth. Figure 2-8 shows the *spinning jenny.* A new kind of loom was also invented. It was run by an engine and could weave cloth much faster than a hand loom. These machines started a revolution in the *textile* (cloth making) industry.

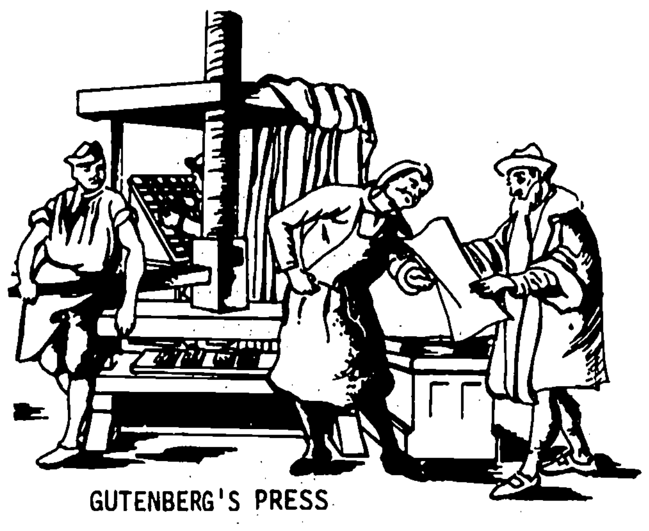


Fig. 2-7. With movable type, large quantities of printed material could be manufactured. The invention of the printing press with movable type is credited to Johann Gutenberg.

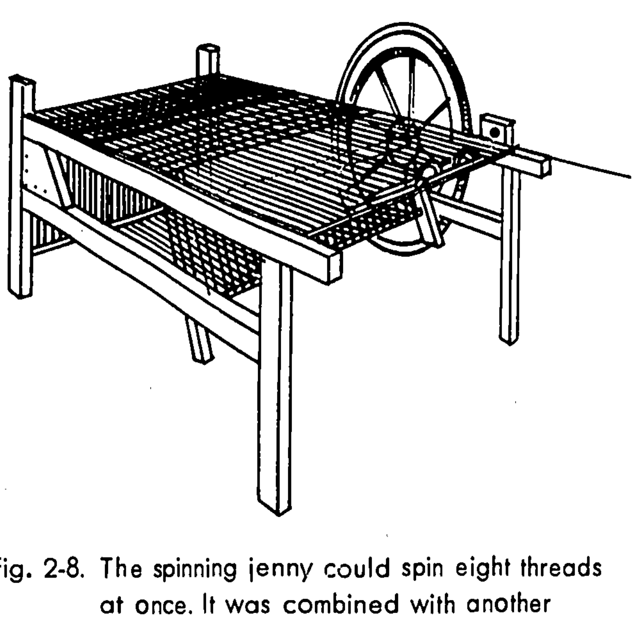


Fig. 2-8. The spinning jenny could spin eight threads at once. It was combined with another invention to make a machine called a *mule* that could spin hundreds of threads.

In 1769 James Watt invented a *steam engine* that did useful work. It ran by steam instead of by *manpower* or *waterpower*. Products could be made near seaports, cities, or wherever the materials of nature were at hand. Later, steam power was used to run boats and trains. Figure 2-9 shows a steamship and a steam locomotive.

The *machines* were too large and too expensive to be set up in a worker's home or shop. Men with large amounts of money built *factories* that housed several machines. They *hired* workers and paid them *wages* (money for their work). These workers were not always skilled craftsmen. A man might run a machine that did just one part of the work (*operation*). Unless he changed jobs, he never learned the other steps in making a product.

Skilled craftsmen had to work in the new factories because machines made goods faster and cheaper then they could be made by *hand labor*. Men and women who had few skills also hoped to earn money by running the machines. Some people even sent their young children to work in the factories.

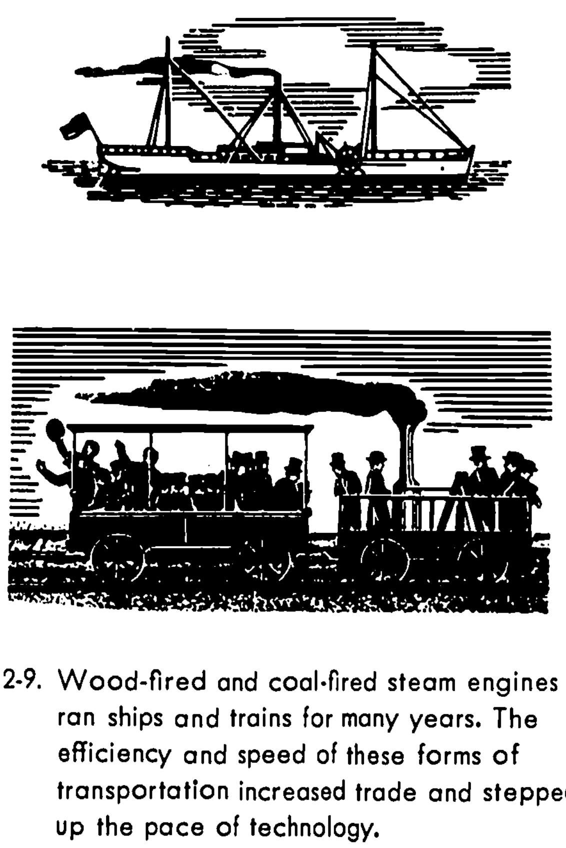


Fig. 2-9. Wood-fired and coal-fired steam engines ran ships and trains for many years. The efficiency and speed of these forms of transportation increased trade and stepped up the pace of technology.

Because so many workers needed or wanted a job, factory owners could pay low wages and make people work long hours. A worker sat or stood at his machine all day with only a few minutes of rest. The factories were gloomy with no heat or fresh air. The machines were dangerous. Children seven or eight years old worked in the factories. After many years an English law was passed to protect child workers. Other laws followed. Factory owners were made to shorten working hours, raise wages, and put in *safety devices* (things that protect the worker from injury). As the *factory system* grew, workers formed labor unions. The unions helped to get shorter hours, higher wages, and better *working conditions.*

When the Industrial Revolution started, most people did not have the *right to vote.* When they moved into cities they learned about politics. After working hours were shortened, people had time to read about government. They began to demand the right to vote and govern themselves. England and other industrial countries became more democratic.

The *efficiency* (good use of time, energy, and materials) of modern industry developed in America. One important step was *mass production* (making many items at one time). The wealth that came from American ideas and abilities raised the *standard of living* (made life more comfortable) and paid for schools, hospitals, and libraries.

In the last fifty years *automatic* machines have been widely used. They were first used in wartime when many workers had to leave their jobs in factories or offices to serve in the war. Machines were invented to can food, send messages, and to do many other jobs that had been done by people. In peace time, automatic copying machines and electric typewriters were developed for offices. Automatic washers, driers, and dishwashers have replaced hand labor in restaurants, hospitals, and many homes. Efficient automatic machines bring many benefits. They bring

new problems too. When automatic machinery goes into a factory, fewer workers are needed. Some people lose their jobs. These workers must be trained for more highly skilled work.

Summary

The world's first *permanent* (lasting) societies grew gradually in Africa, Asia, and the Americas. These people developed the first construction and manufacture as we know them. They *devised* (invented) efficient ways to meet their needs for food, water, shelter, and clothing. The making of beautiful things also grew in these first societies.

About 3500 years ago technology started to spread to Europe. The Greeks improved the ideas they took from Africa. The growth of manufacturing in Greece went on for more than 1000 years. Later, the Romans built an empire and improved technology in *practical* (useful) ways. Knowledge and skills spread through Europe during the Middle Ages.

In the period called the Renaissance, ships came back from other lands with ideas, manufactured goods, and materials of nature that were new to Europe. People devised new ways of using them and made important new inventions. Many people earned money enough to live in comfort, and they wanted beautiful things. European artists and craftsmen learned to make fine rugs, perfumes, glass, and other goods.

In the late 1700's, Europe began to change again. Machines replaced hand labor. Engines replaced manpower and waterpower. Workers left their own small shops to work for factory owners. Working conditions were very bad at first. See Fig. 2-10. New laws made the factory system better, Fig. 2-11.

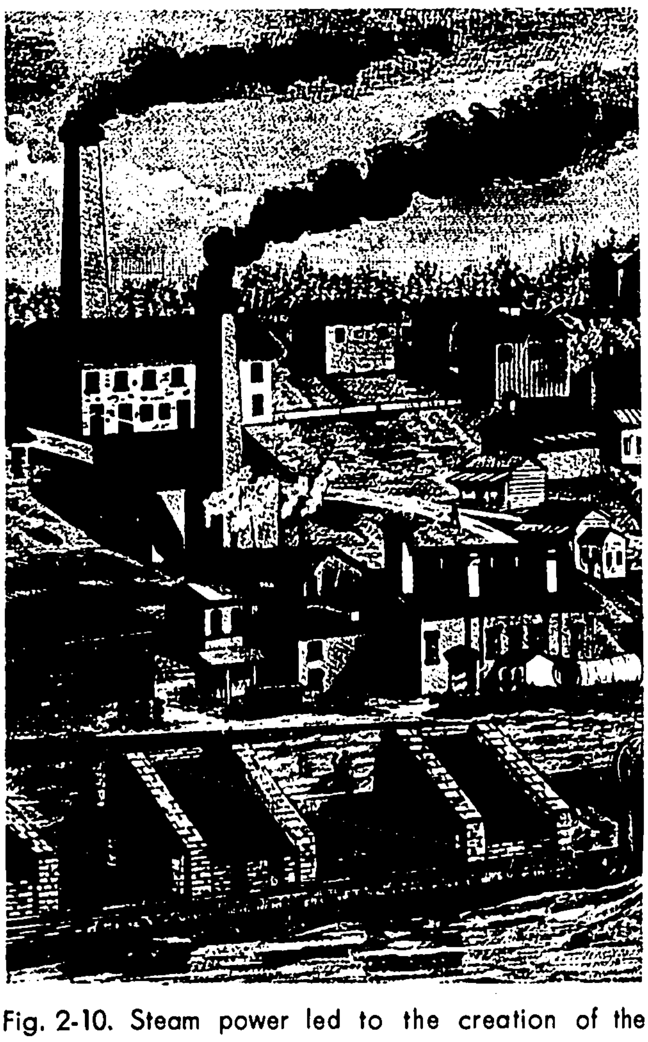


Fig. 2-10. Steam power led to the creation of the factory system of manufacturing. In manufacturing centers, factories were crowded together, as shown here. They were often cold and drafty and had poor lighting. Often children had to work in these factories for many years.

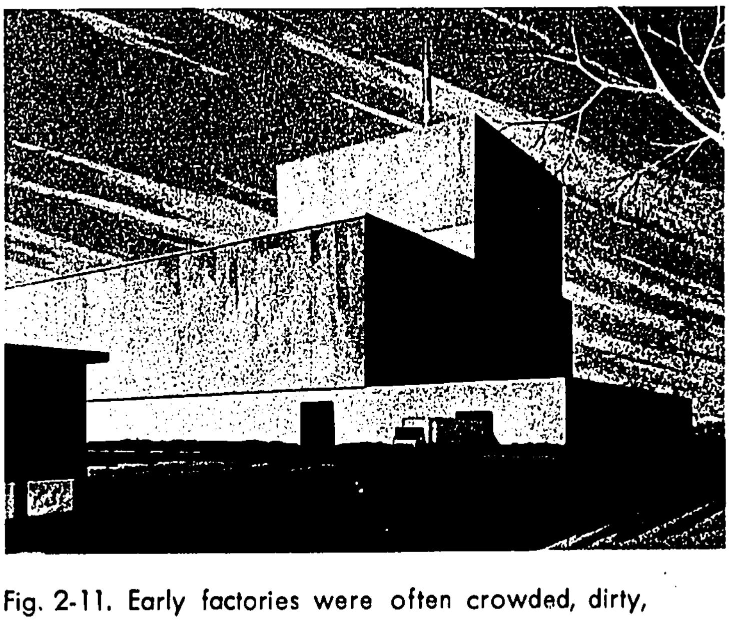


Fig. 2-11. Early factories were often crowded, dirty, and cold. Modern factories are more pleasant, efficient, and pleasing to the eye.

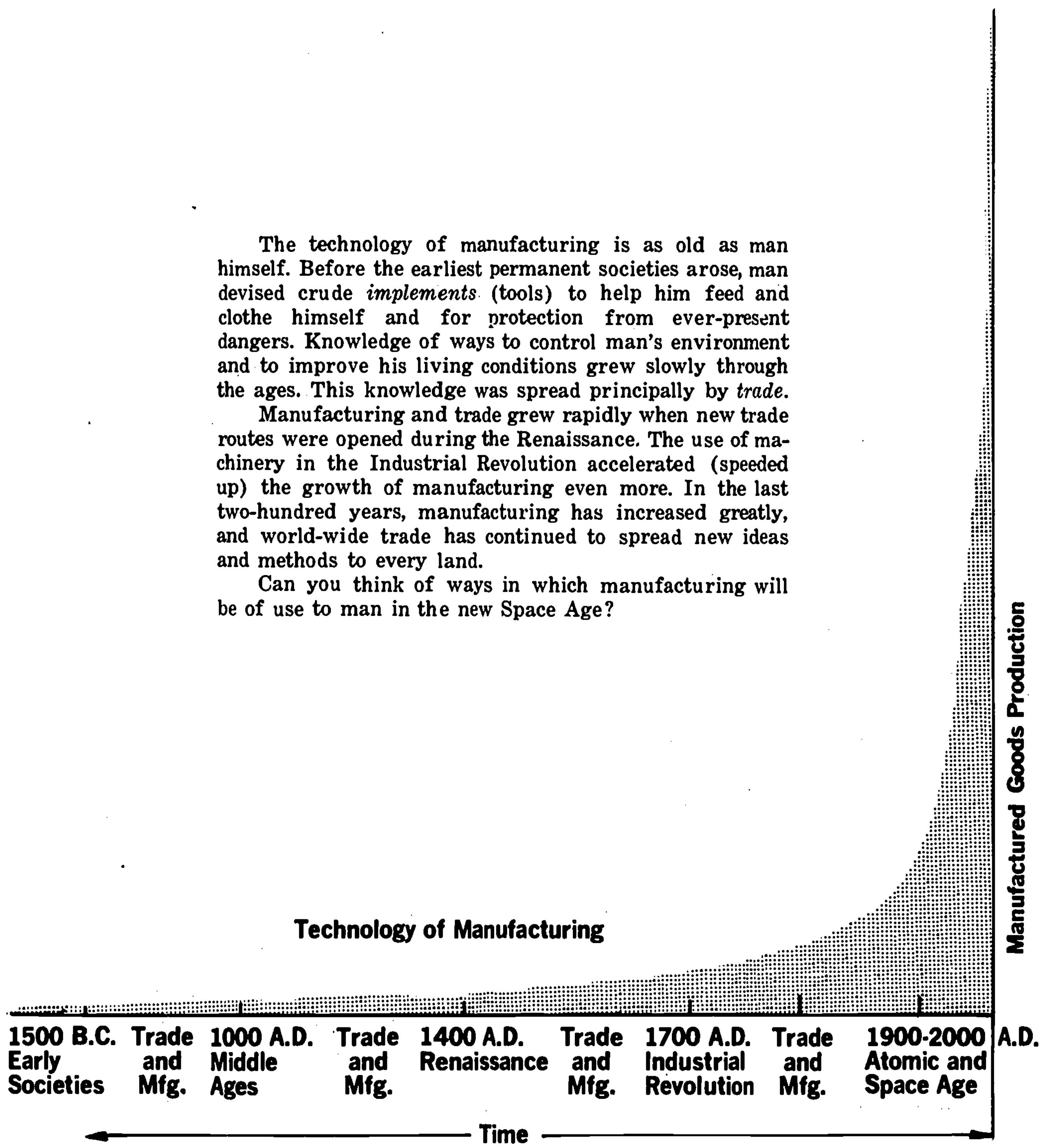
During the Industrial Revolution workers formed labor unions and won the right to vote.

Manufacturing became most efficient in America with mass production. America became a wealthy country with a high standard of living. In the last 50 years automatic machines have brought more benefits. They have replaced many kinds of hand labor. Machines have also brought new problems. They have replaced many workers who must learn a higher skill to get a new job.

The technology of manufacturing is as old as man himself. Before the earliest permanent societies arose, man devised crude *implements* (tools) to help him feed and clothe himself and for protection from ever-present dangers. Knowledge of ways to control man's environment and to improve his living conditions grew slowly through the ages. This knowledge was spread principally by *trade*.

Manufacturing and trade grew rapidly when new trade routes were opened during the Renaissance. The use of machinery in the Industrial Revolution accelerated (speeded up) the growth of manufacturing even more. In the last two-hundred years, manufacturing has increased greatly, and world-wide trade has continued to spread new ideas and methods to every land.

Can you think of ways in which manufacturing will be of use to man in the new Space Age?



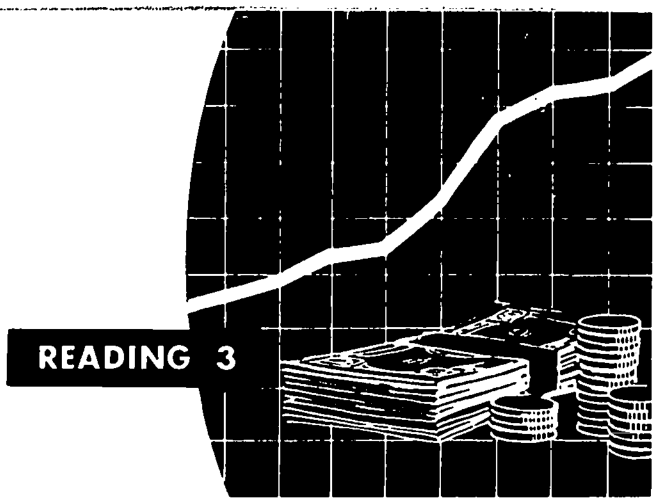
Technology of Manufacturing

Terms to Know

industry	Mercantile Period	writing	safety devices
constructing	standard of living	specializing	factory system
manufacturing	Industrial Revolution	trading	working conditions
shape	spinning jenny	goods	right to vote
barter	textile	merchants	efficiency
household system	steam engine	trade	mass production
materials of nature	manpower	smelted ores	automatic
metal ores	waterpower	labor unions	permanent
devised	machines	Roman Empire	practical
firing	factories	Middle Ages	nuclear radiation
smelting	hired	architects	
crafts	wages	Renaissance	
evolved	operation	hand labor	

Think About It!

1. Suppose that the following things disappeared completely and could not be replaced. In each case, how would your life change?
   A. Wheels
   B. Printing presses
   C. Pure water
2. Research scientists have recently learned that *nuclear radiation* is useful in making cloth that will not rot and mildew. Can you think of some other possible new ways of producing goods that will benefit all people?



Manufacturing and the Economic System

Industry (construction and manufacturing) has never been able to make everything that everyone wants. In the United States, companies are free to decide which *goods* they will make. They can buy materials, make products, and try to sell the products at a *profit*. Profit is the extra money, from sales, left over after paying for materials, rent, wages, and other *costs*.

Most people cannot afford to buy all the goods they want, but each buyer is free to choose what he will buy, Fig. 3-1. Freedom of choice, which both producers and buyers have, is a part of the American *free enterprise* system, Fig. 3-2.

People also buy and sell *services* (work that benefits people and improves products). A doctor is paid to help cure illness and heal injuries. A mechanic is paid to repair autos, trucks, or other machines, Fig. 3-3. A teacher, a barber, and a professional ballplayer each performs a service. In the United States no one is forced by law to become a

Fig. 3-1. Our economic system is based on money. We exchange money we have earned for goods that we want.

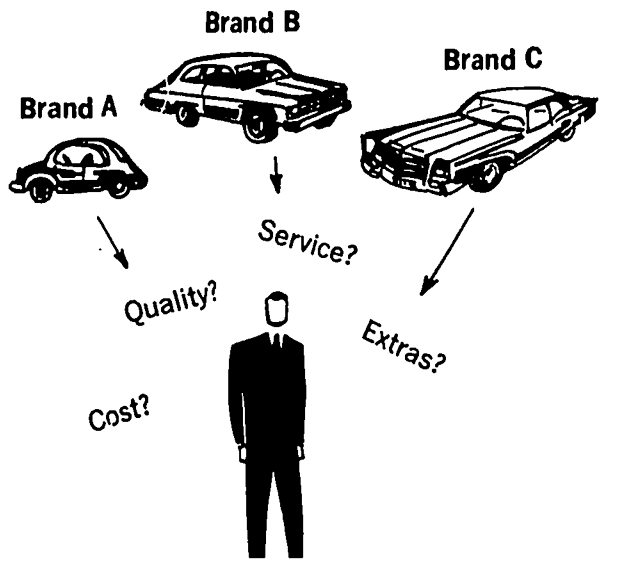


Fig. 3-2. The free enterprise system works for the consumer's benefit. Usually, several brands of similar goods are produced. The customer is free to choose from among them.

Fig. 3-3. Services provided by a manufacturer help sell his products. This service station attendant provides good services so that customers will return to buy more of his goods.

doctor, a mechanic, or a ballplayer. No one is forced to buy the services of these people. There is a great deal of choice about buying and selling services. This is another part of the free enterprise system.

Supply and Demand

People form new companies to make and to service goods because they hope to make a profit. They work to improve their goods and services, to devise new products, and to make a profit. A product must be something that *consumers* (buyers) will choose to buy. This gives the consumers some power. Whatever they are willing and able to buy is called *demand.* Whatever is made and offered for sale is called *supply.* The demand for a product or service always affects the supply of that product or service. For example, if consumers buy only small cars, manufacturers will keep on making them. If consumers buy only large automobiles, manufacturers will make these instead. Sometimes, the quality of the service that is available will decide which cars are bought.

Most goods are provided by more than one firm. In the auto industry several firms make and service small cars. These firms *compete* (each tries to do better than the other) for sales. They try to learn just what the demand will be so they can supply exactly what the consumers want.

Competition helps keep the quality of goods from falling very low. The consumer will buy products that work well and that require little servicing. He will not buy a poorly made auto, for instance, if there is a better one for sale at the same price.

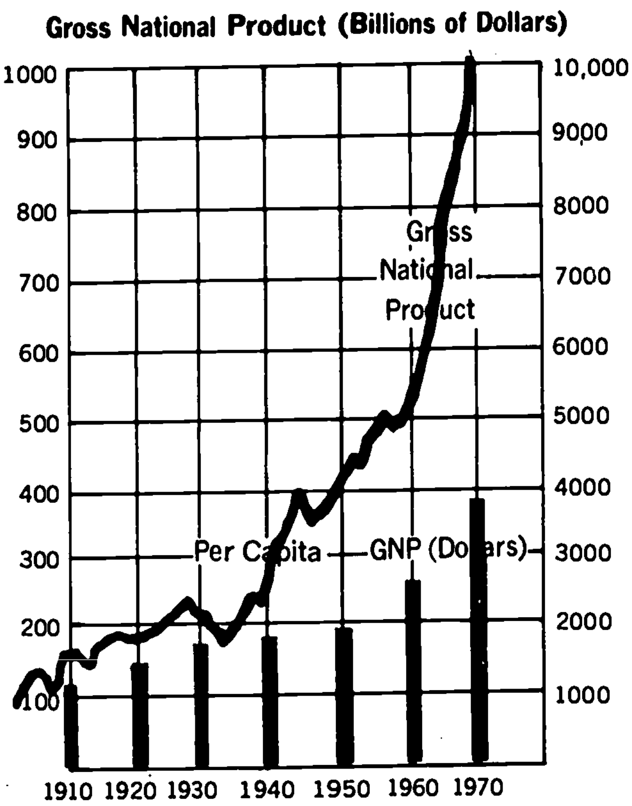


Fig. 3-4. Our economic growth is shown by our GNP (Gross National Product) and the per capita GNP. The GNP is the value of all goods and services produced in the nation. The per *capita* GNP (the amount of the GNP produced by each person) is figured by dividing the GNP by the number of people in the nation.

Economic Growth

Each year the total worth of all goods and services sold in the United States is figured. This total worth is called *Gross National Product* or *GNP*. As the number of people in America keeps growing, sales keep growing too. Each year people buy more houses, more schools and school books, more food, more haircuts, more of almost everything than they bought the year before. Comparing last year's GNP with the figure for the year before shows the *economic growth* (increased business) of the United States, Fig. 3-4.

The System of Manufacturing

To understand our *manufacturing system* (orderly way of making things), you should

think of it as having three main parts: (1) *input*, (2) *process*, and (3) *output*, Fig. 3-5. To work well, the system must be *managed* (planned, organized, and controlled), and so must each of its parts.

Input is whatever goes into a system. There are six kinds of input to the manufacturing system:

1. *Natural resources:* the animal, vegetable, and mineral materials of nature,
2. *Financing:* money in the form of cash or *credit* (borrowing power),
3. *Capital:* buildings, machines, equipment, tools,
4. *Energy:* for example, the energy of falling water, wind, or fuel; electricity; the sun's radiation; and atomic energy,
5. *Human resources:* people, and
6. *Knowledge:* knowing what to do and how to do it.

Each input is important, Fig. 3-6. If even one is missing, a company cannot succeed.

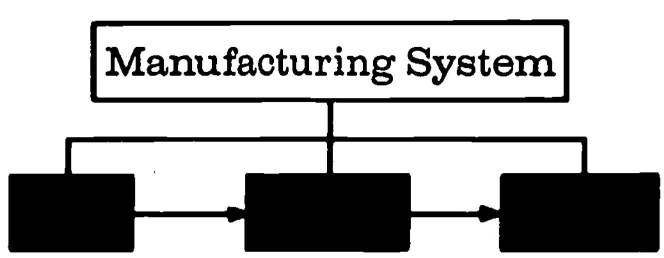


Fig. 3-5. The manufacturing system has three main parts: input, process, and output.

A *process* is an activity that has a purpose or goal. In industry, all activity must be efficient and skillful. All processes are carefully chosen and tried out. When a process works well and is put to daily use, it is called a *practice*. In industry three kinds of practices are important, Fig. 3-7:

1. *Management practices,*
2. *Production practices,* and
3. *Personnel practices.*

Management practices make sure everything goes according to plan. One important part of a management job is to make decisions.

Production practices change the forms of natural resources into products to be sold. Some of these practices also are used to service goods when they need maintenance or repair.

Personnel practices make sure that the skills of workers are used in the best way. Workers are helped to understand each other and get along together, and their jobs are made more satisfying.

Output is whatever comes out of a system. The outputs of industry are material goods. One branch of industry is called *construction*. It produces goods like office buildings, houses, water-supply systems, highways, and bridges. Materials for these products are *assembled* (put together) at the place where they will be used.

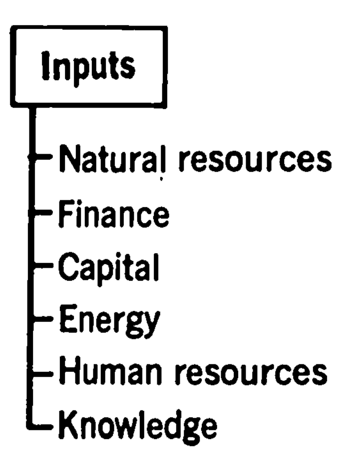


Fig. 3-6. Each of these inputs is necessary before manufacturing can even begin.

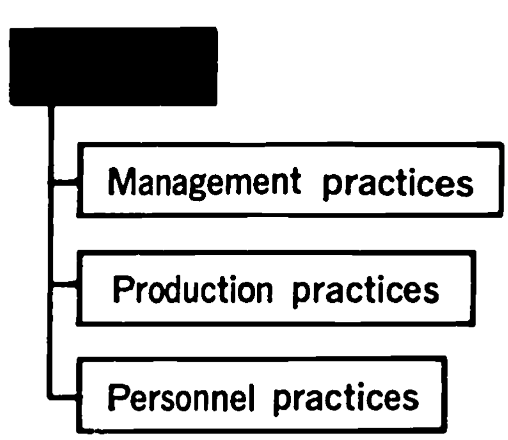


Fig. 3-7. There are three kinds of manufacturing practices. They work together efficiently to process all the inputs.

Another branch of industry is called *manufacturing*. It produces goods like radios, cans of paint, newspapers, and hammers. These products are assembled in a plant or factory.

Durable and Nondurable Goods

The United States government has a system for putting the outputs of manufacturing into *classes* (groups). There are two main classes: *durable goods* and *nondurable goods*, Fig. 3-8. Products that usually last at least three years are called "durable", Fig. 3-9. Products that usually last fewer than three years are called "nondurable", Fig. 3-10. Figure 3-11 shows different kinds of goods in these two groups. Those on the left are nondurable. The ones on the right are durable.

Summary

The *system of supply and demand*, with companies competing for sales and profit, brings many benefits.

1. The consumer has a wide choice of goods and services.
2. The quality of a product may become poor, but it will not stay poor if a better product can be made for the same price.

The manufacturing system has three main parts: input, process, and output. Each day we enjoy using the durable and nondurable outputs of production.

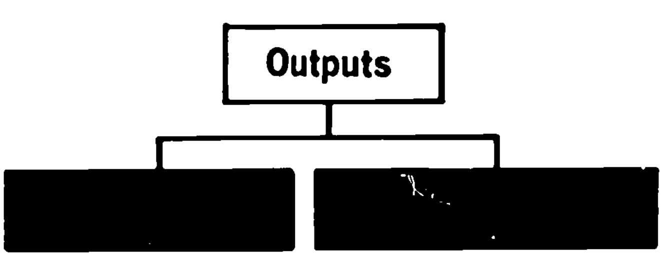


Fig. 3-8. Manufacturing has two kinds of outputs.

Fig. 3-9. These goods are called *durable*. This means that they are expected to last for three years or longer.

Fig. 3-10. Most of these goods are called *nondurable*. This means that they will be used up in fewer than three years.

Terms to Know

industry
goods
profit
costs
free enterprise
services
consumers
demand
supply
compete
competition
Gross National Product (GNP)
economic growth
manufacturing system
input
process
output
managed
natural resources
financing
credit
capital
energy
human resources
knowledge
practice
management practices
production practices
personnel practices
construction
assembled
manufacturing
classes
durable goods
nondurable goods
system of supply and demand

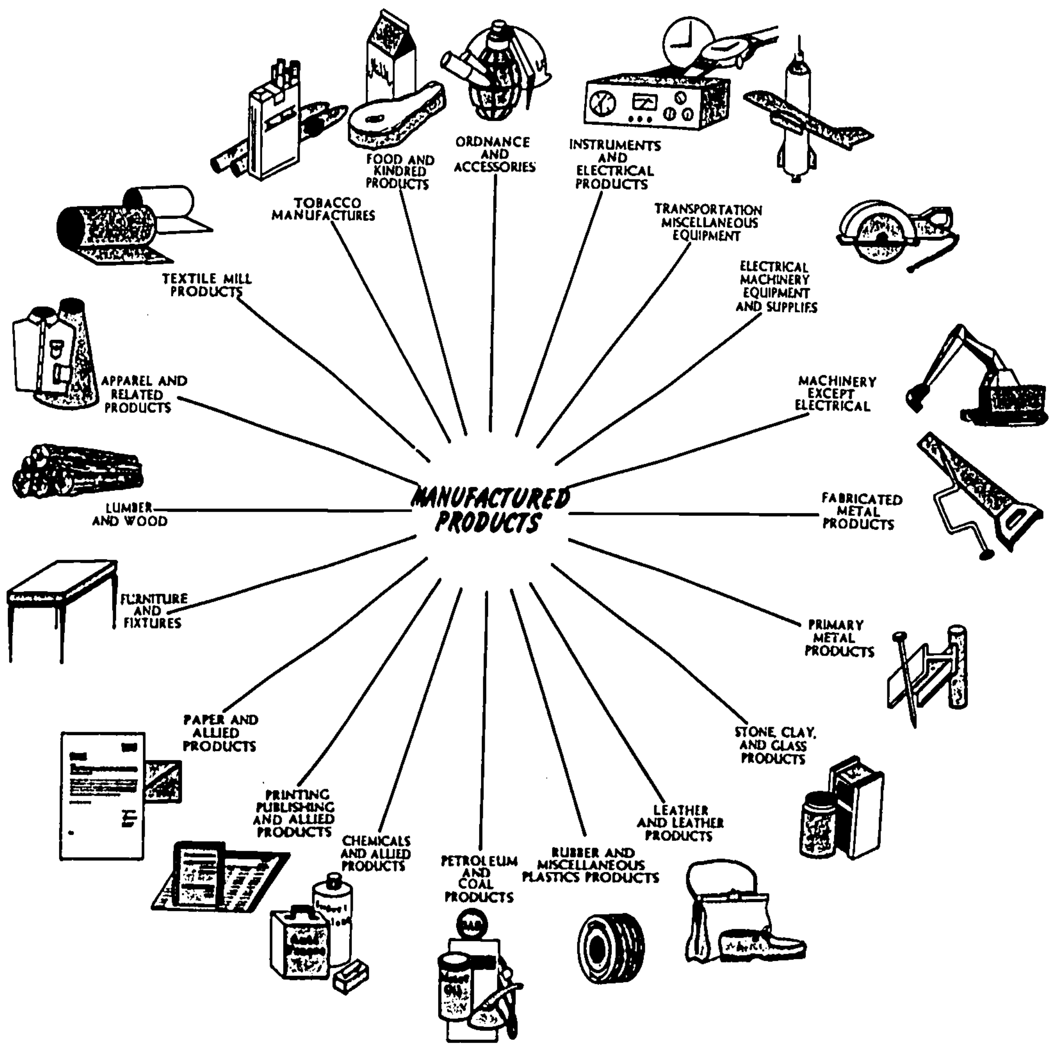
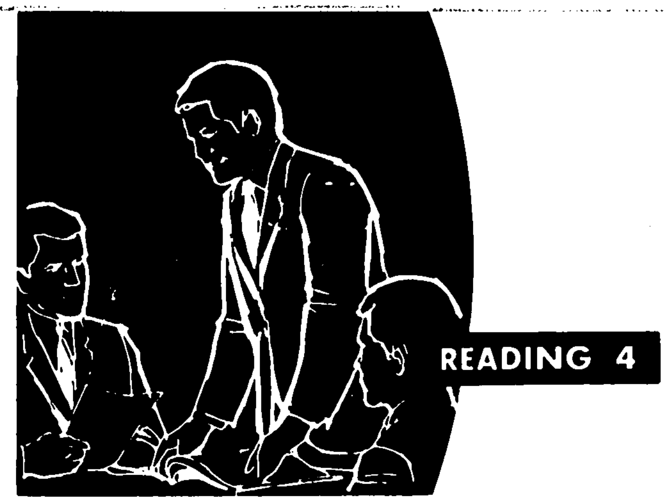


Fig. 3-11. This system of grouping manufactured products was prepared by the United States Bureau of Census.

Think About It!

1. What could you do, as a *consumer*, if a company's products became poorer in quality than you wanted them to be?
2. What could a company do if its *natural resources* were used up or no longer available?

Manufacturing Technology



The word *technology* comes from a Greek word meaning skill in doing something. To do things well is to be skillful. The word ending *logy* means "a science of". *Science* is knowledge which has order or system. Tech*nology*, then, is the science of expert doing or skillful action.

Man is a very active animal, so he has many different kinds of technology. They depend on what he is doing. One kind you will read about is *manufacturing technology*, the science of making material goods skillfully. All of our material goods made in factories and plants are mainly the result of manufacturing technology.

There are three kinds of manufacturing technology: (1) *management technology* (2) *production technology*, and (3) *personnel technology*, Fig. 4-1. In making goods, as in making meals, there are steps to follow. Before your mother prepares a meal, she decides what she will cook. Then she goes to the store and buys the food she will bring home for the meal. She checks often as she cooks the food to be sure it is properly done. When she does these things, she *plans*, *organizes*, and *controls*, Fig. 4-2. These steps are also followed in a modern plant. They are called the technology of manufacturing management.

Manufacturing Management Technology

Planning (deciding what work must be done), *organizing* (getting everything ready for work), and *controlling* (overseeing the work) are kinds of management in a modern plant. The technology of manufacturing management, then, is the science of planning, organizing, and controlling work.

Management is sometimes called "getting work done through other people." To do this, *decisions* are made. Your mother decides what to cook, how to cook, and how to serve the food. But she is not the only one who decides what to eat, and she is not the only

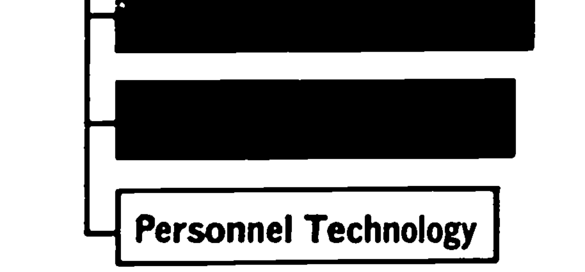


Fig. 4-1. There are three divisions of manufacturing technology.

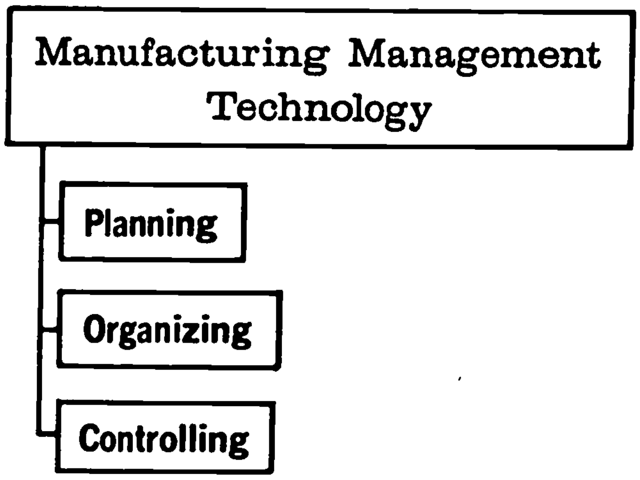


Fig. 4-2. Manufacturing management technology has three functions.

one who does the work. These decisions are also important in manufacturing management. Planning, organizing, and controlling are not done by managers alone. Other people help to carry out these actions (*functions*), Fig. 4-3.

Manufacturing Production Technology

The making of manufactured goods is called *production*. Production of goods goes through stages called (1) *preprocessing*, (2) *processing*, and (3) *postprocessing*, Fig. 4-4. The technology of production is called the science of preprocessing, processing, and postprocessing.

Fig. 4-3. Many people are involved in planning, organizing, and controlling.

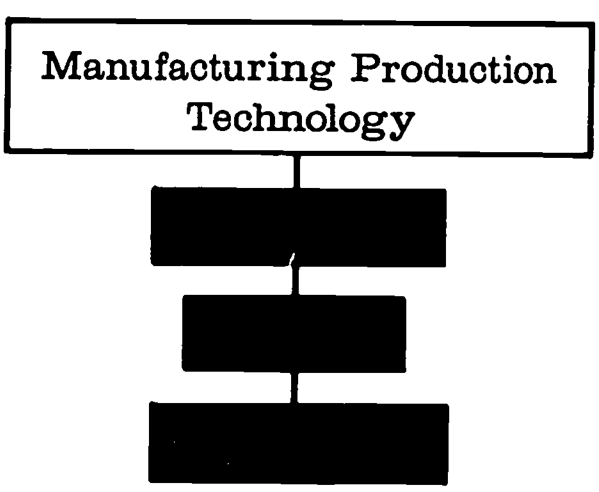


Fig. 4-4. There are three functions of manufacturing production technology.

Before material can be *processed* (changed in form), it must be brought to the place where it will be used. Then it is prepared for use. Let us follow your mother from the time she first decided to serve corn-on-the-cob until the time when you bite into a hot, buttered ear. She must first decide where to buy the corn. Then she picks out the most appetizing ears of corn, brings them home, unwraps them, and stores them in the refrigerator until just before they are to be cooked. Then she takes them out of the refrigerator and takes off the husks and silk.

This is much like the preprocessing step in a big plant. Before materials can be changed into products to be sold, they must be *ordered, unpacked, handled, stored,* and *protected*. Before your shoes were ready to be worn, much happened to the natural leather from which they are made. The hide was cut from a cow and was probably brought to the factory in its natural state. Then it had to be handled and stored carefully so that it could be used.

After material has been preprocessed, it is ready to be *processed*, Fig. 4-5. The raw corn-on-the-cob is simple to process. The ears are put into a pan of boiling, salted water to cook for a short time. When all ears are juicy and tender, they are removed from the water and taken to the table. Raw leather is usually rough and stiff. It must be worked in

Fig. 4-5. These helicopters are being processed. Before they leave the factory, they will need many kinds of processing.

many ways before it can be bent to the shape of your foot and polished brightly. This processing, unlike cooking corn-on-the-cob, may take much time and the work of many people.

Production does not end when the product leaves the factory. After a product has been processed and delivered to the buyer, it may still need to be *installed* (put in its proper place), *maintained* (kept in good condition), *repaired* (fixed), or *altered* (changed). After your meal, if there is still corn-on-the-cob left, your mother may change its form. She may scrape the cooked corn from the cob and mix it with meat and other foods for another meal. This is postprocessing. The heels of your shoes may wear down after you have worn them awhile. If your parents take them to a shoe repairman, this is also postprocessing. Usually, these activities are called *servicing*. The knowledge needed for both postprocessing and processing is the same, but the knowledge is used at a different time and in a different place.

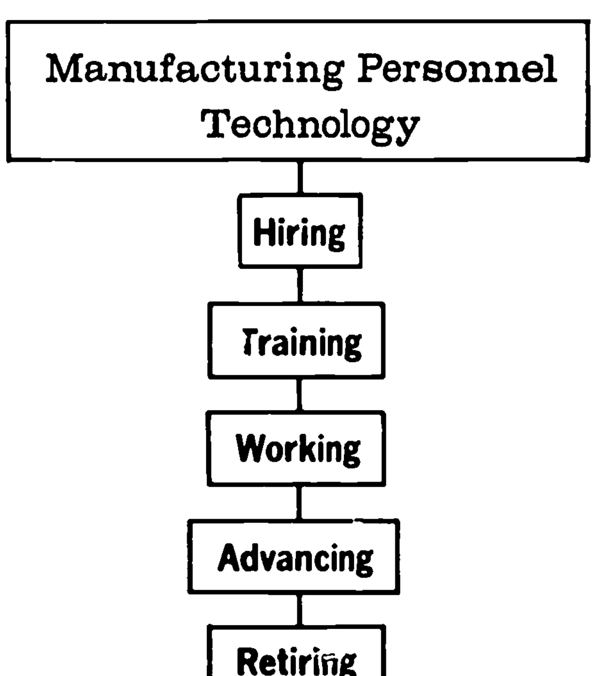


Fig. 4-6. Manufacturing personnel technology has five functions.

Manufacturing Personnel Technology

In manufacturing, *personnel technology* is the name given to (1) hiring, (2) training, (3) working, (4) advancing, and (5) retiring workers, Fig. 4-6. The technology of personnel work, then, is called the science of *hiring*, *training*, *working*, *advancing*, and *retiring*. Your mother finds jobs you can do well. Then she shows you how to do them. In the same way, personnel workers find what kinds of work are best for different people, what ways are best to teach them new jobs, and how to help people improve their work, Fig. 4-7. Every day more people see that if each person is to do his best work and be satisfied, those who manage him must know what kind of person he is and how he feels. Personnel programs are planned to find out how this can best be done.

Summary

Manufacturing technology is the science of skillful action in a modern manufacturing plant. The three kinds of manufacturing technology are:

1. Management technology (planning, organizing, and controlling),

Fig. 4-7. Interviewing and testing are basic steps in hiring.

2. Production technology (preprocessing, processing, and postprocessing), and
3. Personnel technology (hiring, training, working, advancing, and retiring).

This course in The World of Manufacturing will help you understand what these stages are and what is done in each of them.

Think About It!

1. Who decides, from the food available, what you will have to eat this evening? How are these *decisions* made in your home?
2. How was your father *hired* for the job he has now? How was he *trained* for his work? How is his work being improved?

Terms to Know

technology	ordering	controlling	altering
science	unpacking	decisions	servicing
manufacturing technology	handling	functions	hiring
management technology	storing	production	training
production technology	protecting	preprocessing	working
personnel technology	installing	processing	advancing
planning	maintaining	postprocessing	retiring
organizing	repairing	processed	

Manufacturing Management Technology

READING 5

You have learned that one important kind of manufacturing technology is management. If someone plans, organizes, or controls activities, he *manages* them.

The activities (*functions*) of management are a part of most work and play. Your parents manage family and home affairs; they plan, organize, and control many activities. Your school principal, with others, manages school activities and events. Your city is managed by elected or appointed officials. State and federal governments are managed. All the practices of agriculture, business, and industry must be planned, organized, and controlled to be successful.

What, then, are the steps in management that are special to manufacturing? How are these steps related to planning, organizing, and controlling?

Fig. 5-1. Surveys are one way of learning consumer demands. This woman is asking the opinion of each member of a family and recording the answers.

Manufacturing Management Stages

Management has six main steps or stages in manufacturing. They are:

1. *Identifying* (finding out) what *consumers* want, Fig. 5-1;
2. *Designing* and *engineering* the product;
3. *Planning* ways to make the product;
4. *Tooling up* (getting tools and machines ready), Fig. 5-2;
5. *Getting inputs* to the system;
6. *Setting up* production and quality controls, Fig. 5-3.

Fig. 5-2. Before production can begin, all the machines used in the manufacturing process must be set up and adjusted so that the right operations are done at the right time. These men are tooling-up drill presses to get ready for production.

Manufacturing Management Technology

During the next several weeks you will learn the stages of management in detail. In each stage there must be planning, organizing, and controlling. Management always means:

1. Planning the work of others,
2. Organizing the planned work so that it will be carried out efficiently, and
3. Controlling the work.

These things are done at all levels of management, Fig. 5-4. Management is also needed in all departments of a plant.

The Planning Function

Without planning there would be confusion in a plant. There are two main kinds of planning: (1) *long-range* and (2) *short-term planning*. Long-range planning gives direction for five, ten, or more years in advance, Fig. 5-5. Men with new ideas in the top levels of management are needed for this

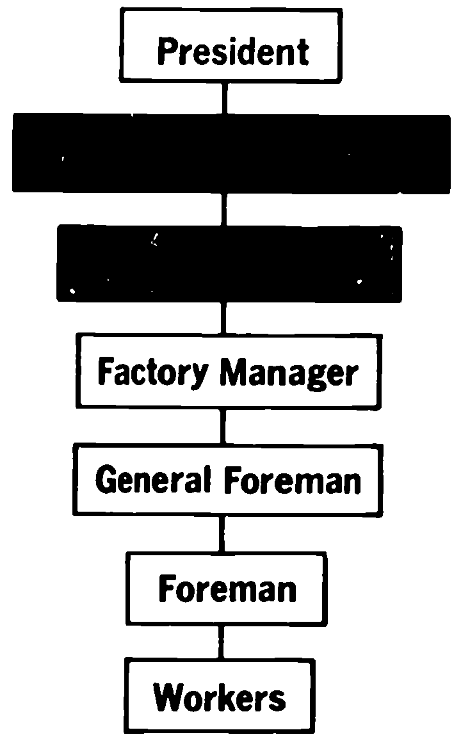


Fig. 5-4. Management has many levels. Each of them is in charge of certain activities within the company.

Fig. 5-3. The inspection on this assembly line is one part of quality control. Inspections are also made all through the process to make sure that the quality stays at a high level.

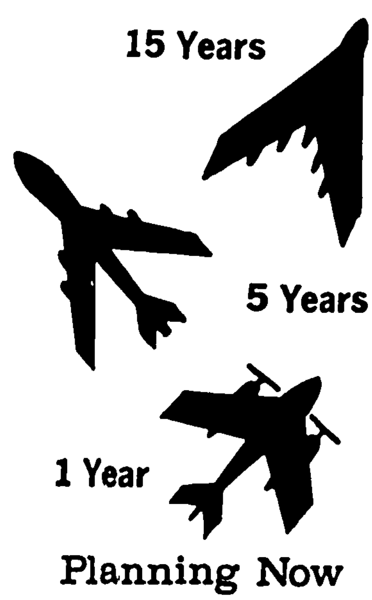


Fig. 5-5. Planning is done for the future as well as the present. Long range planning gives the company direction so that it and its products will not become out of date.

work. Short-term (short-range) planning gives direction for day-to-day, and month-to-month details. This kind of planning is done by middle and lower-level management, Fig. 5-6.

Both kinds of planning (1) set up company rules and goals, (2) carry out research, and (3) design and engineer products, processes, and plant. All planning, then, is: (1) formulating (deciding), (2) researching, (3) designing, and (4) engineering, Fig. 5-7.

A company's leaders must *formulate* (decide) long-range and short-range goals, or objectives. They must set up policies that will decide the future of the company and make sure that it will grow. Should we build a new plant? Should we develop a new product line? Will we *merge* (combine) with another company? These and other questions must be thought about and answered by *top-level management*.

Today, most firms cannot exist or grow without the knowledge gained through *research* (careful hunting for new ideas). Some large firms have their own research workers and laboratories, Fig. 5-8. Smaller firms may have research done for them by public or private research companies. It is important to learn more about new materials, new processes, and new products.

Research gives answers to such questions as: What have other people already found out? (*Retrieving.*) What are our present surroundings like? (*Describing.*) What will

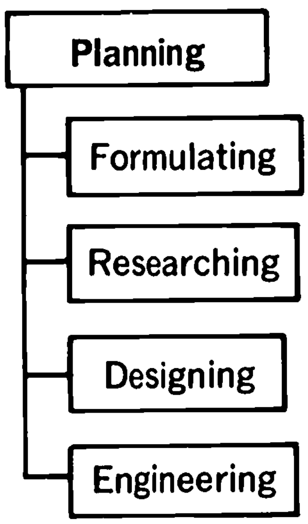


Fig. 5-7. There are four steps in planning.

Fig. 5-6. Setting goals and objectives by long range planning is done at the higher management levels of a company.

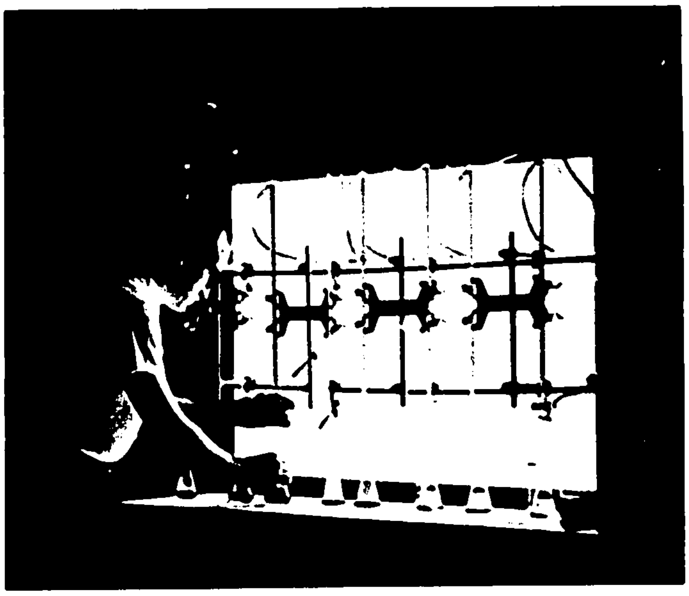


Fig. 5-8. Research is needed for company growth and product improvement. Most companies do some research. It is often expensive, but it more than pays for its cost.

happen if I change some things without changing others? (*Experimenting.*)

In manufacturing, many people *design* products and the ways to make them, Fig. 5-9. Several solutions (answers) to each problem of design must be thought up. A product designer may give a new form (shape) or new colors to a product. A personnel man may design a suggestion system for workers. An engineer may design a new machine to move heavy workpieces from one work place to another. The best solutions are chosen after all solutions to the problem have been considered.

After products or processes are designed, they must be *engineered* (planned out). Engineers, *technicians* (people with special knowledge or skills), and *draftsmen* work at engineering details. Production processes and the best way for men and machines to work together must be planned. Costs are figured (estimated). Special tools are developed to help in making the product. Materials and *work flow* are *scheduled* (what is done first, second, next, and so on until the product is finished). A *quality control system* is set up (deciding what kind of work will be allowed to leave the plant and what kind must be thrown out as poor quality). These are a few examples of the engineering function of planning.

Designing and engineering, together, are sometimes called *development.*

Fig. 5-9. Many kinds of products are manufactured in different styles and models. The shape and size of these ladders are the result of product design.

The Organizing Function

The planning function provides the plan (goals). But if the plan is to succeed so that work will be done quickly and well, a plant must be *organized* (set up). There are two main kinds of organizing:

1. Structuring, and
2. Supplying, Fig. 5-10.

Small plants with few workers often do not have a regular *structure.* Large plants have very complicated structures. A factory owner or manager must have workers to do each job. He must give his company a structure by finding out the work to be done, where it will be done, and who will do it.

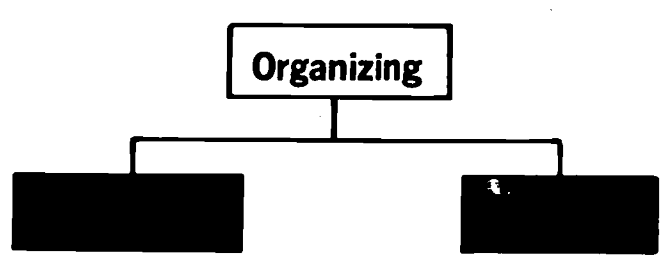


Fig. 5-10. The organizing function of manufacturing has two parts.

The structure of a company can be shown on an *organization chart,* Fig. 5-11.

After the plant is structured (formed), workers must be employed (hired or supplied) for each management and production job. Equipment and material must be bought. Sometimes parts used in the work are made by other companies (*subcontracted*). When these parts are received from the *subcontractors,* they are assembled into the final products.

Organizing continues all the time. Improvements are made when they will help the company to grow.

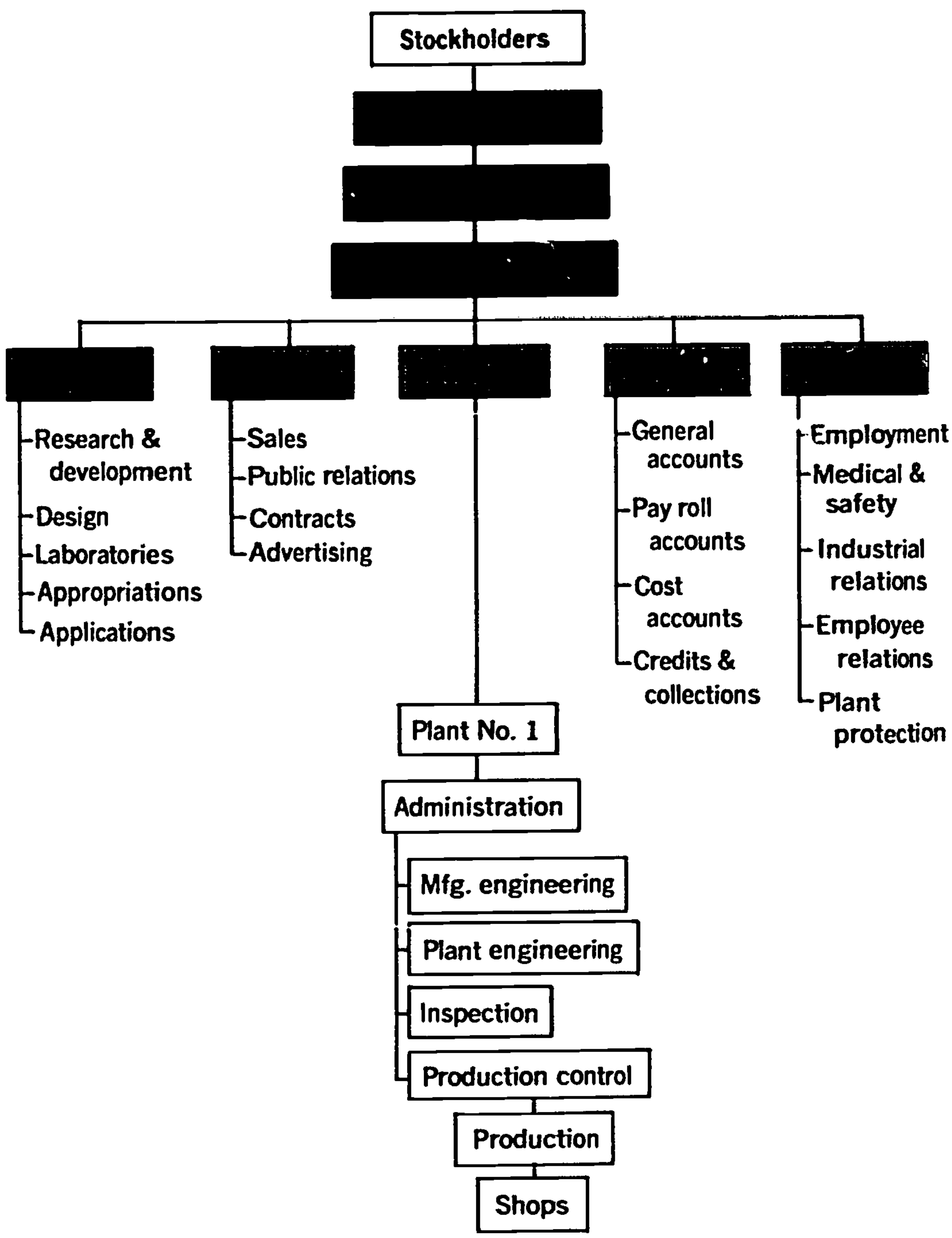


Fig. 5-11. This chart shows one type of company organization. Note the different levels of management. There may be other plants besides the one shown here.

The Controlling Function

To plan and organize the work carefully is not enough. Workers, equipment, and material must also be *controlled*. The four main kinds of control are:

1. Directing,
2. Monitoring,
3. Reporting, and
4. Correcting, Fig. 5-12.

Directing means supervising and coordinating the work (keeping in right order). Workers, equipment, and materials all must work together well. Someone must direct the work in each department of a plant and at each level of organization.

Monitoring means checking or keeping close watch. Many people in a plant check to see if the work is going according to plan, Fig. 5-13. *Inspectors* are monitors. They check the quality of a product while it is being made. Even research is checked to see if it is going smoothly. Another kind of monitoring is keeping lists of goods (*inventories*) so that enough stock can be kept on hand for the work to be done, Fig. 5-14. Keeping records of when workers are on the job is still another kind.

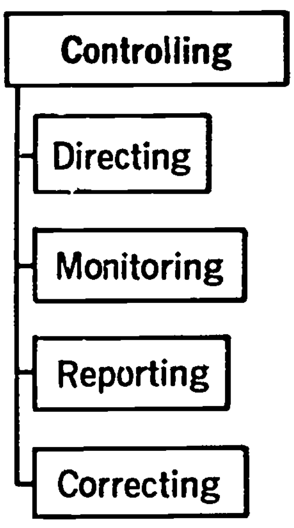


Fig. 5-12. The controlling function of manufacturing management has four parts.

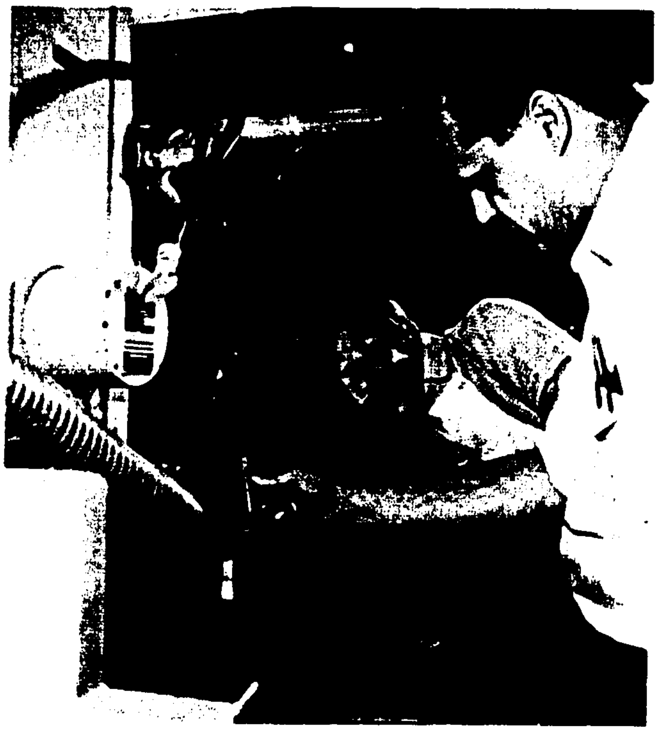


Fig. 5-13. Foremen help monitor the work of the company. This man is observing the workers and giving advice when needed so that the work will be done according to plan.

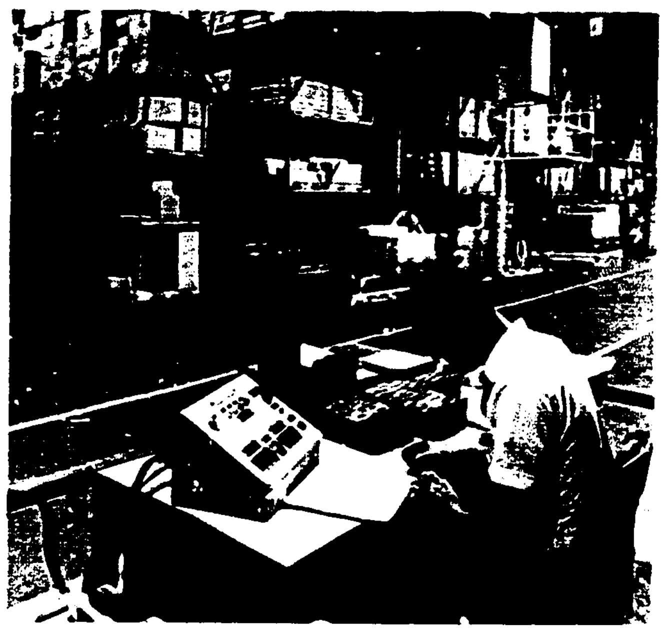


Fig. 5-14. This partly automatic warehouse is controlled by one dispatcher. The automatic equipment enables him to quickly find out the inventory levels and to report low supplies to the purchasing department.

Reporting is important. If an inspector finds that the workpieces are not the right size, he must report this to a *responsible* person (someone who can do something about it). If the supply of a material is low, this is also reported.

Correcting is a controlling function. When a report shows that some work should be corrected, the work must be done over again according to the plans. Sometimes the plans must be *revised* (changed). If corrections are not made, the company will lose time, materials, and money.

Summary

Many people in a plant perform management activities (functions). They must plan, organize, and control. All three activities go on at the same time.

We can think of management as a story in six parts (steps), starting with finding out the products the consumer (buyer) wants. Production changes the materials into the products to be sold. Management makes sure that production runs smoothly.

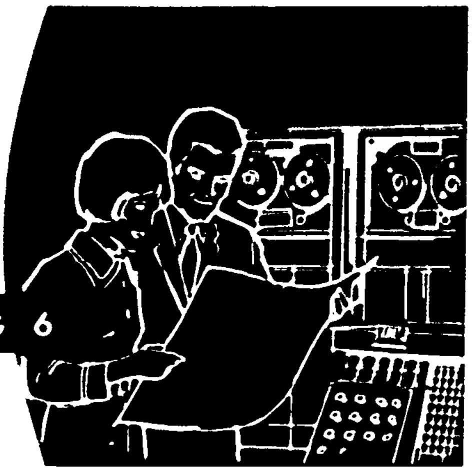
Your next reading begins the story. Read each lesson carefully. You will learn how planning, organizing, and controlling are part of each step in the story.

Terms to Know

manages	work flow
functions	development plan
identifying	scheduled
consumers	quality control system
designing	organized
engineering	structure
planning	organization chart
tooling up	employed
inputs	subcontracted
long-range planning	subcontractors
short-term planning	controlled
formulate	directing
merge	coordinating
top-level management	monitoring
research	inspectors
retrieving	inventories
describing	reporting
experimenting	responsible
engineered	correcting
technicians	revised
draftsmen	

Think About It!

1. What kinds of *long-range planning* and *short-term planning* are done in your family? Give examples of each.
2. How is a homework assignment *controlled* by a teacher? by a student?



READING 6

Inputs to Manufacturing

To manufacture any product, a company needs six main kinds of *inputs:* (1) natural resources, (2) energy, (3) finance, (4) capital, (5) human resources, and (6) knowledge. If all six of these inputs are not used at the same time, the manufacturing process breaks down. Production may stop, workers may be laid off, or the company may lose money. So, a manufacturer must get inputs as efficiently as possible.

Natural Resources

Natural resources are taken from the earth, sea, and air, Figs. 6-1, 6-2, and 6-3. They may be used in their natural state (for example, water) or they may be processed (as iron ore is processed into steel). Natural resources are the most important input because the kinds and amounts of these resources *determine* (put a limit on) the kinds of goods that men can make.

Fig. 6-1. Most of our natural resources are taken from the earth.

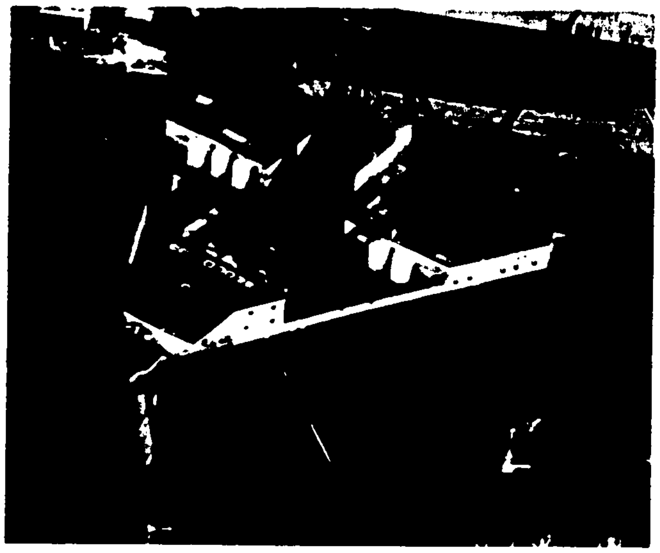


Fig. 6-2. Petroleum is a natural energy source. This drilling rig can search hundreds of feet under the ocean to extract (take out) natural crude oil.

Fig. 6-3. The air, as well as the earth and sea, gives us natural resources. This man is checking tanks of oxygen which has been "reduced" from the atmosphere.

Some natural resources, like cotton, vegetables, and fruits are easily replaced. Others, like petroleum and natural gas, can be replaced only after thousands of years. So, men must *conserve* (protect) their natural resources. Land can be saved by preventing floods and *erosion* (soil being washed away). Timber supplies can be restored by planting trees to replace those that have been cut down or burned. Minerals can be saved by better ways of mining, and much fuel can be saved by more efficient use. America also protects her own supply of resources by *importing* (bringing in) raw materials from other countries. To save some natural resources, men are working to develop *synthetic* (man-made) *resources*. Two of these features are: (1) plastics to replace mineral and wood products, and (2) atomic power to replace natural fuels.

Energy

An input that is very important to manufacturing is *energy*. Manufacturing plants are usually located near a *source* (supply) of energy so that large amounts of money are not needed to get power for the plant. Sometimes, an area rich in one kind of natural resource does not develop manufacturing. This happens because a cheap source of energy is not at hand. Waterpower, coal, and petroleum are basic sources of energy that are often used to make electricity and other kinds of power. Power from ocean tides, energy from the sun's rays, and nuclear energy are also being developed, Fig. 6-4.

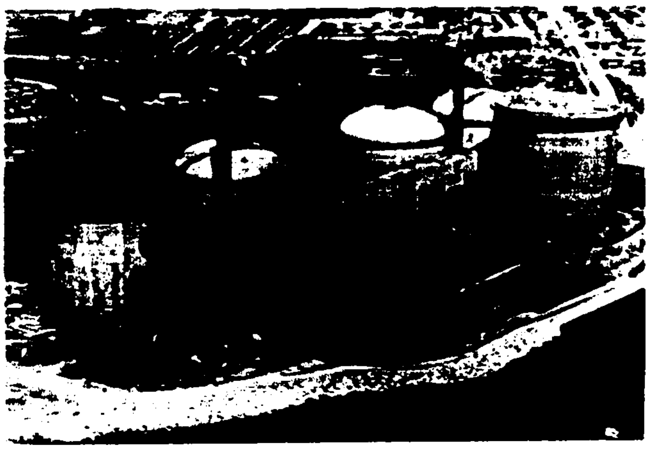


Fig. 6-4. This nuclear power station will produce electricity, a necessary input to manufacturing.

Finance and Capital

Working capital is money (finance) used to buy raw materials and to hire workers. *Fixed capital* is tools, machines, and factory buildings. Both kinds of capital help men in production, Fig. 6-5. In other words, manufacturers need money for natural resources, for energy input, and for machines. Many workers make *private consumer goods* like bread, shoes, or petroleum. Many other workers make *fixed-capital goods* like machines, tools, or new inventions.

Working capital is created when people save money in banks, Fig. 6-6. For the small saver, this might mean giving up certain pleasures. For people with large incomes, it is easier to save their money than to find ways to spend it. The buying of *stocks and bonds* by savers gives manufacturers working capital (money or finance) to buy fixed capital. The people who supply the savings which help make up capital are called *investors*.

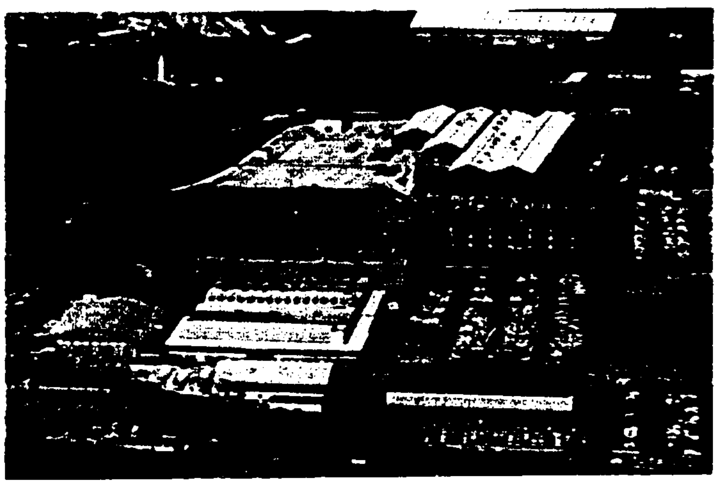


Fig. 6-5. Money is needed for capital spending. All these buildings are fixed capital of the company.

Human Resources

Human resources (people) are a very important input. People *perform* (do) work or labor. Labor is sometimes physical (the worker on the assembly line), or it may be mental (the work of a researcher, Fig. 6-7). It is often a mixture of both physical and mental work. The supply of labor is always changing. In the summer many students enter the *labor force* (groups of working people). Recently, many women have entered the labor force.

The skills of the labor force also change. Since machinery is now widely used in industry, many workers learn how to *operate* (work with) machines, Fig. 6-8. Others learn how to repair the machines. Because business firms are complicated, some workers become supervisors, accountants, bookkeepers, and secretaries.

Many things *determine* (decide) which people will do a certain kind of work. People will either find a job where they live or they will move to a location near a job. They must have the skills, training, and knowledge needed for a job. They must receive certain *compensation* (pay) for their work.

Fig. 6-6. Banks lend the money saved by millions of people. Manufacturers may borrow the money to buy land, buildings, or equipment.

Fig. 6-7. Many highly skilled and trained persons are needed by manufacturing. This researcher is looking for improved medicines.

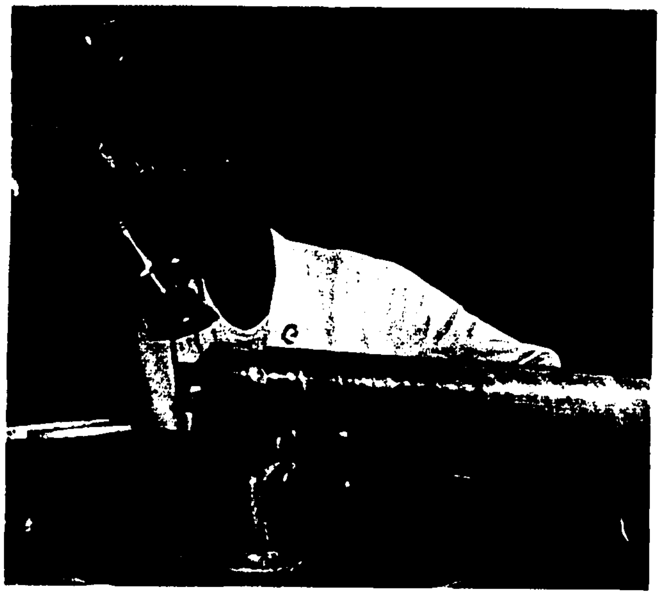


Fig. 6-8. Training this man for his job is a function of manufacturing personnel technology.

Fig. 6-9. Manufacturing needs people with knowledge. One-third of all the people in the United States are involved in schooling of some kind.

Fig. 6-10. These graduates will become part of the labor force. Education is becoming more important to manufacturing all the time.

Whether they find their job through a school, an employment agency, or newspaper advertisements, many people learn that the best jobs go to those with good education. This will be even more true in the future when manufacturing processes and organization become more *complex* (complicated) and *specialized* (requiring special skills or training). Today almost all workers in the labor force are staying in school until high school graduation. After high school, many go on to other schools or colleges for specialized training. Most workers return to school every few years for extra training and education.

Knowledge

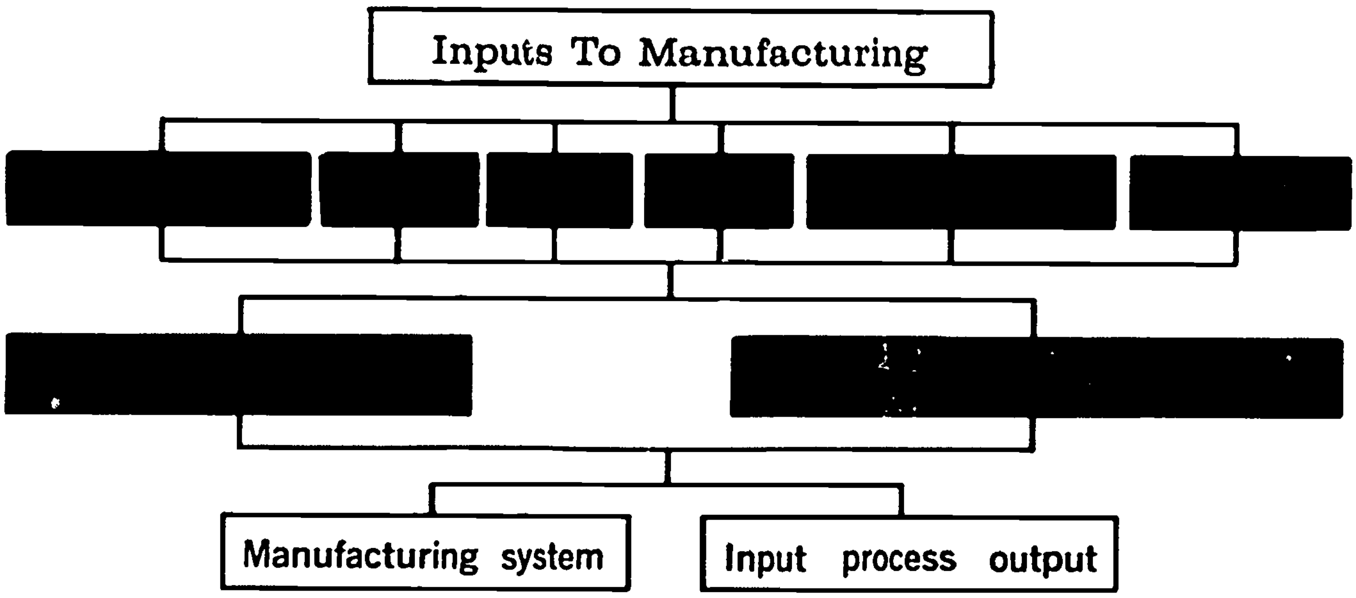
Even when natural resources, energy, finance, capital, and human resources are at hand, the knowledge that workers have is very important, Fig. 6-9. Without knowledge, a company could not succeed.

You have learned that there are three important kinds of knowledge needed in manufacturing: (1) manufacturing management technology, (2) manufacturing production technology, and (3) manufacturing personnel technology. The people (human resources) who work in manufacturing must have these kinds of manufacturing knowledge.

In addition to manufacturing knowledge, workers must bring other kinds of knowledge to the job. Natural sciences and mathematics are important. History, law, and economics are also important. In fact, most of man's knowledge is used by the manufacturing labor force in a large plant, Fig. 6-10.

Summary

Many inputs play a part in production. Some of them are: natural resources, capital goods, labor, management, the number and skill of workers, and the financial condition of the country. There are many others. Six main kinds of inputs are: natural resources, energy, finance, capital, human resources, and knowledge. These inputs are necessary in today's manufacturing system.



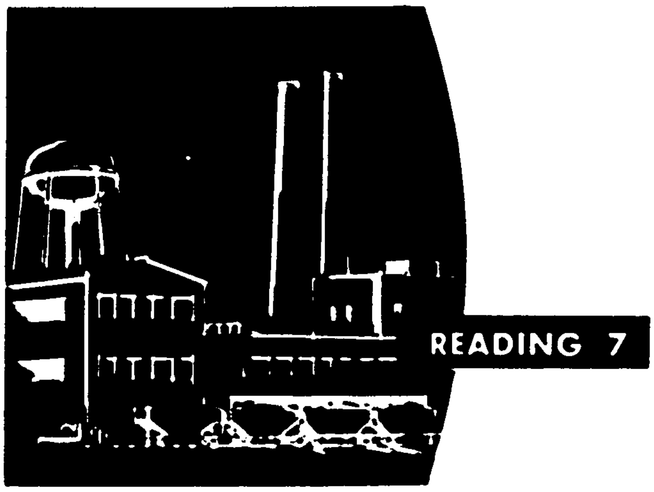
Terms to Know

inputs
natural resources
extract
determine
conserve
erosion
importing
synthetic resources
energy
source
finance
  a. working capital
  b. fixed capital
private consumer goods
fixed-capital goods
stocks and bonds
investors
human resources
perform
labor force
operate
compensation
complex
specialized

Think About It!

1. How would your life change if these *natural resources* could no longer be used?
   a. Wheat
   b. Petroleum
   c. Trees
2. What would happen to manufacturing companies if all people took their *savings* out of the banks at one time?

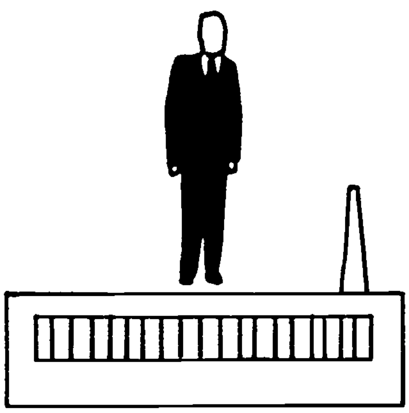
Organization, Ownership and Profit



The *ownership* of manufacturing companies may take one of two forms. The owners are either (1) personally involved in the ownership, called a *proprietorship*, Fig. 7-1, or a *partnership*, Fig. 7-2, or (2) they can create another *legal entity* (person), such as a *corporation*, Fig. 7-3, which, in a legal sense, personally excludes them from the company. In either case, the owners of these types of manufacturing companies expect to make *a profit from the sale of their products.*

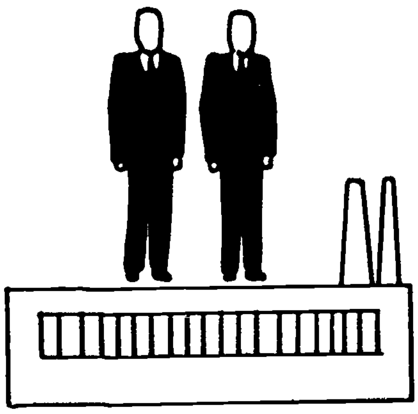
Types of Organization

A common type of industrial organization (company) is the *proprietorship.* One man owns the company and is *liable* (legally responsible) for all aspects of the company, Fig. 7-1. There are both advantages and disadvantages to this kind of ownership. Generally, the single owner has the advantage of (a) having complete control of the company, (b) getting all of the profits, and (c) *dissolving* (ending) the company whenever



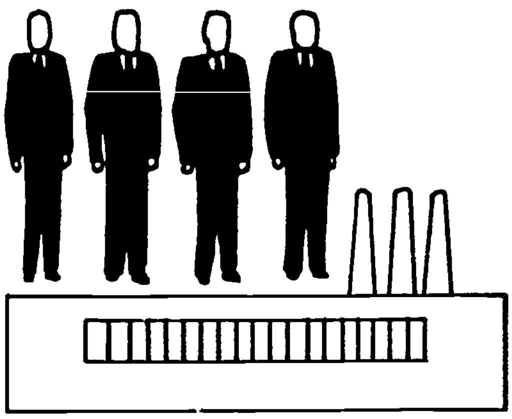
Proprietorship

Fig. 7-1. In a proprietorship, one man owns and operates the company.



Partnership

Fig. 7-2. A company with two or more owners may be a partnership. In this form of organization each owner is responsible for operating the company successfully.



Corporation

Fig. 7-3. Stockholders own corporations. Each share of stock entitles the owner to a voice in the corporation.

he wishes. The largest single disadvantage is that he may lose his own personal property to pay the *debts* (expenses) of his company.

A partnership (two or more owners), Fig. 7-2, generally has the same advantages and disadvantages that the proprietorship has, with the exception that everything (decisions, profits, losses, and company debts) must be shared equally by the *partners* (owners).

The other form of ownership, *corporations* (Fig. 7-3), grew out of the need for owners to (1) exclude their personal property from the company, and (2) amass (gather) large sums of capital (money) to create large manufacturing plants that could meet the great demand for products. This form of ownership creates an *artificial man* whose rights and responsibilities are defined by law in its charter. All corporations must receive a *charter* (written permission) in order to come into existence. The charter states what the corporation will produce and how much *stock* (amount of ownership) it will sell to persons who wish to become *stockholders*. The amount of ownership a stockholder purchases is shown by the number of *shares* (units of ownership) on a *stock certificate*.

Advantages of a corporation are these:

1. It can raise large amounts of capital.
2. Its shares of ownership can easily be given or sold to other people.
3. It never dies.
4. Unlike the other forms of ownership (partnership or proprietorship), its owners cannot be made to pay for all of the debts of the company.

Corporations must operate by rules and regulations. Most rules that corporations have to follow are in the public interest. Therefore, corporations cannot operate without obeying the laws that control them.

These rules also allow corporations themselves to combine and make *mutual agreements*. They may agree to share an order for raw materials so that each may get lower costs per unit. They may share a single building so that they will have less expensive rent. They may share hauling vehicles (trucks, trains, ships) in order to have lower freight rates.

Another kind of organization is known as the *holding company*, Fig. 7-4. This is a corporation which (rather than producing goods itself) owns stock in other corporations which do produce goods. *Interlocking directorates* occur when the same people are elected to the boards of several different corporations. This means that a director making decisions in Corporation A may be influenced by the fact that he is also a director in Corporation B.

When two or more existing corporations combine to form an entirely new corporation, it is called a *merger*. When the government controls mergers, it does so to help *consumers* (people who buy the companies' products). *Mergers have several advantages:*

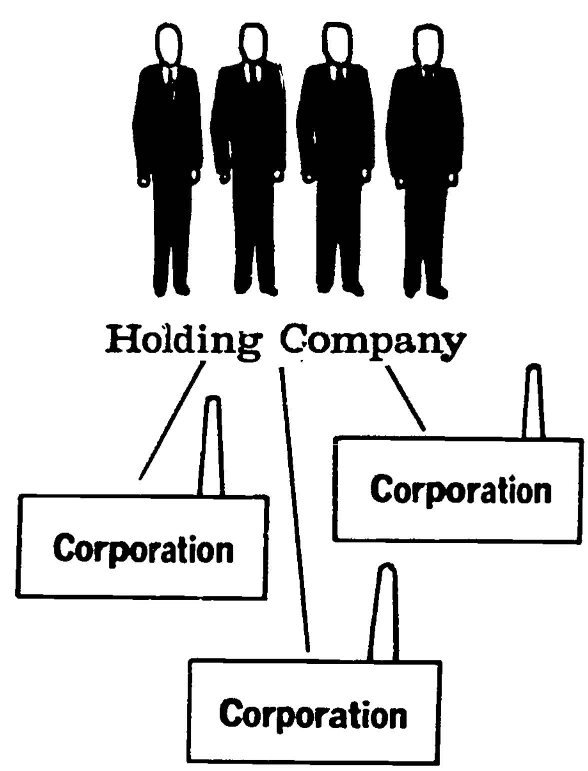


Fig. 7-4. Holding companies own stock in other corporations. Sometimes the result of this structure is greater efficiency in manufacturing management.

1. They can produce a greater variety of goods.
2. They can more efficiently use their employees and buildings.
3. They have time and money to spend for developing new products and investing in (purchasing) expensive and complex (complicated) machinery.
4. They can cut down costs by large-scale purchases.

The term *business combination* is often used instead of merger. There are three different types of business combinations: (1) *horizontal combinations*, (2) *vertical combinations*, and (3) *conglomerate combinations*. A horizontal-type business combination unites two or more companies selling the same product to the same types of customers. See Fig. 7-5.

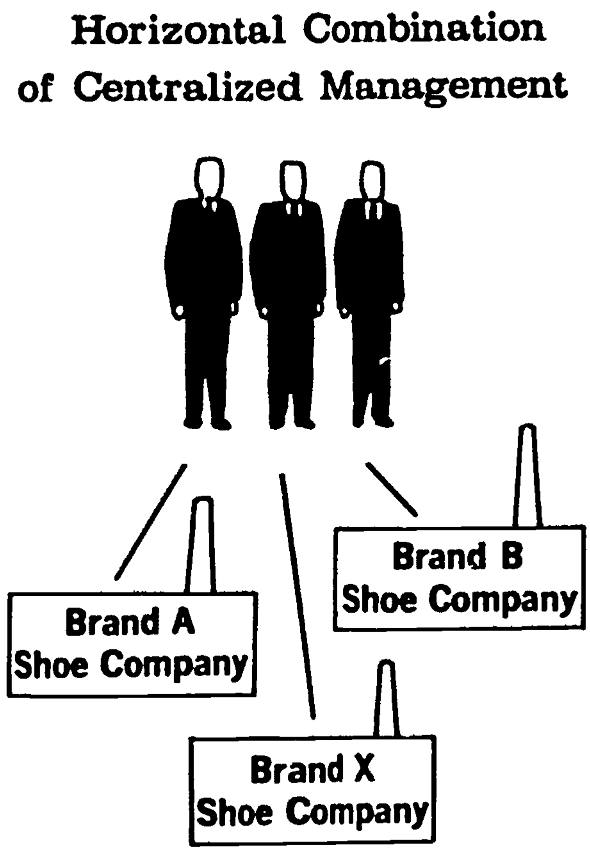


Fig. 7-5. Combining the management of several companies may improve efficiency.

A *vertical-type combination* unites two or more companies which have common characteristics of production, materials, or sales. Vertically organized companies work at different levels in sequence from (1) extraction of raw materials through (2) production levels to (3) sales and (4) service of a final product. See Fig. 7-6.

The third type of combination, and recently most popular, is the *conglomerate combination*. It unites two or more companies which formerly bought and sold products neither horizontally nor vertically related to each other. See Fig. 7-7.

Ownership and Organization of Corporations

Stockholders own the corporation itself; and the corporation in turn owns land, ma-

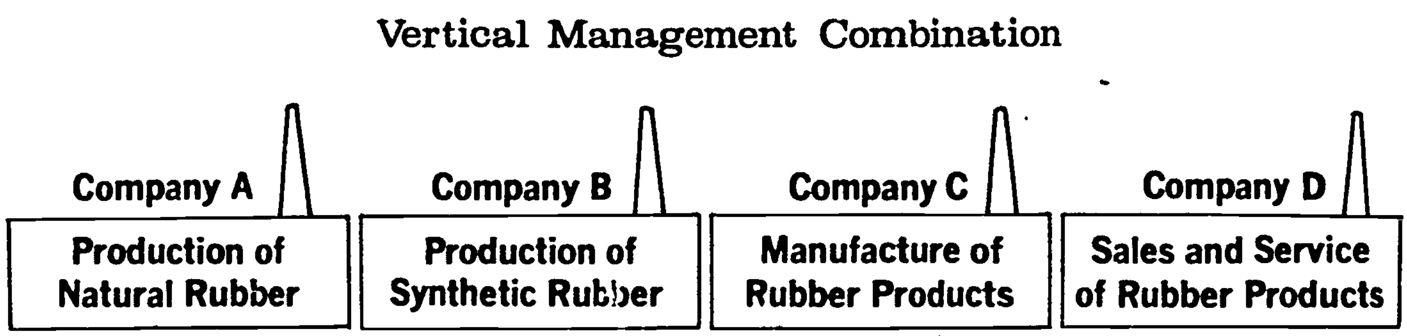


Fig. 7-6. In a vertical management structure, one management system controls a variety of different manufacturing processes. However, each of the processes is contained within one company.

chinery, buildings, and other property. The stockholders do not control the company directly. Instead they elect a *board of directors*, Fig. 7-8. The directors then elect a chairman of the board, a treasurer, and other necessary officers. The directors also hire the people who will manage the company.

Stockholders usually have one vote for each *share* of stock they own. When the *annual* (yearly) *meeting* is held to elect the board of directors, most small stockholders with only a few votes find it impractical to attend. Sometimes they send their votes in to be cast by another person. This is called *voting by proxy*. As long as they receive their share of the profits (*dividends*) regularly, they usually are satisfied that the company is being run efficiently. Often their dissatisfaction is shown by selling their stock and perhaps purchasing shares in another corporation that they feel will pay better dividends.

There are two types of stock. *Preferred stock* pays a set (fixed) dividend which is always paid before any other dividends. *Common stock* pays dividends from what is left after the dividends on the preferred stock are paid. If profits are large, common stock may pay a larger dividend than preferred stock. If profits are low, preferred stock will pay a dividend, but common stock may pay either a lower amount or none at all.

Corporations also raise money by borrowing. The certificate which they give to the *lender* (buyer) is called a *bond*. Bondholders get *interest* on their loans regularly, but they cannot help elect the board of directors, as stockholders can. Interest must be paid even if the company does not make a profit. Bonds appeal to careful investors who want a *fixed* (sure) *return from their investment* (payment in return for putting their money into the company).

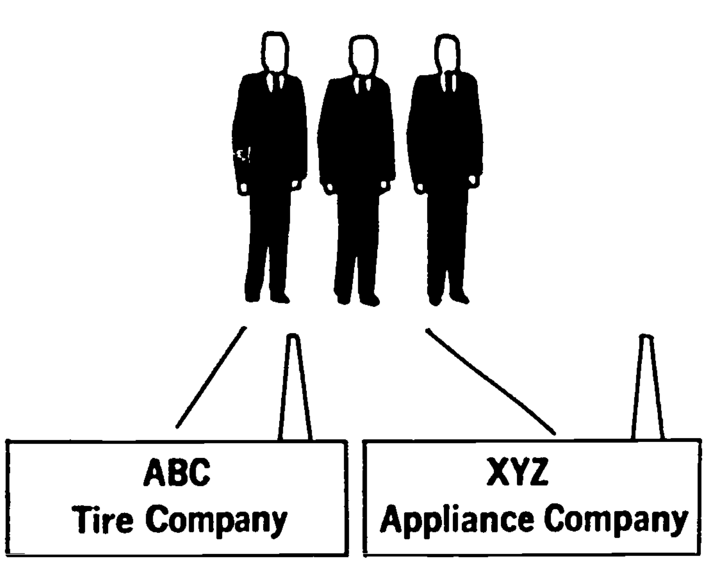


Fig. 7-7. A conglomerate combination unites two companies which formerly bought and sold products neither horizontally nor vertically related to each other.

Fig. 7-8. The stockholders elect a board of directors to hire the company management.

Many Americans have invested their savings in the *stock market,* Fig. 7-9. Today, almost twenty-million Americans, or one out of ten persons in the U. S., own shares of corporation stocks.

Profit

As you have learned, *profit* is an important part of our free enterprise system. The form of ownership may affect the profit. The profit depends on the price the customer pays for the goods. If the price is higher than what it costs the manufacturer to produce the goods, a profit is made. If the price is the same as the cost, or less than the cost, there is no profit.

In the past, *competitors* (businesses having similar products to sell who each try to get its share of the buyer's dollar) frequently joined together and agreed to charge a *standard price* (the same price to every customer). In this way, they could all be sure of making a large profit and be sure that they would not lose buyers to cheaper products. When these combinations controlled almost the complete supply of a particular item, they were known as *monopolies* or *trusts.* Buyers became upset at the high prices charged by these monopolies, so they asked the federal government to take part. The government then passed a series of *antitrust laws* to protect the buyer from these monopolies.

To further protect the buyers, the government *regulates* (controls) the prices charged by public utilities. A *public utility* is the monopoly of a good or service (water, gas, and electricity) which is necessary for all people. Each utility receives permission from the government to be the only seller of that good or service in an area. Because they have no competition, the government also controls what prices can be charged and how much profit can be made.

Because people would not invest their savings if they did not get some return from their investment, some profit is necessary for all companies. The amount of profit made by a company helps people decide whether they will invest in it, or whether its present stockholders will take their money out. If a soft drink company is making a large, steady profit, many people will invest in it. If they are making a small profit, or no profit at all, investors will look for another company that will give them a larger return from their investment.

The profits of a company are affected by many *factors* (conditions). Efficient management may make decisions which keep costs

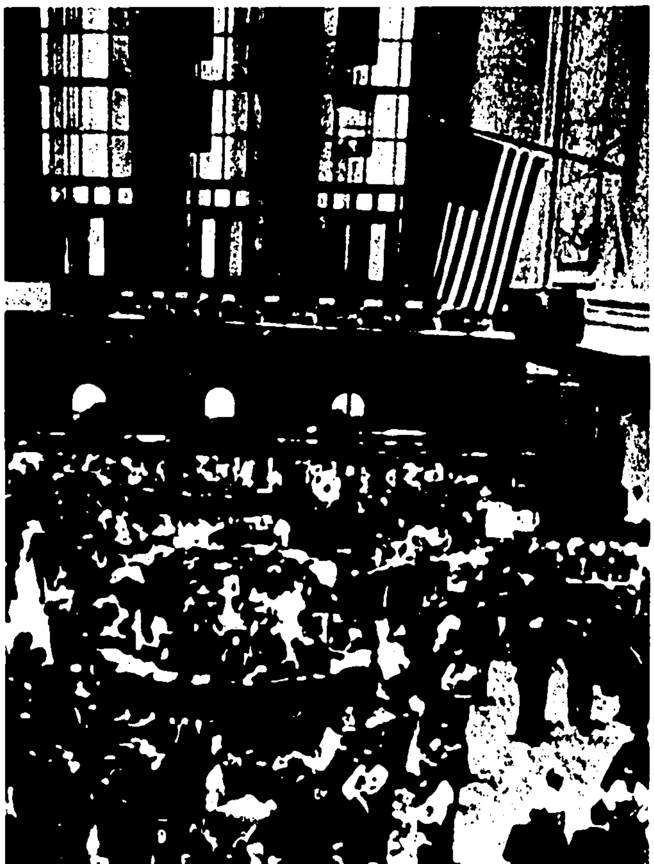


Fig. 7-9. Millions of shares of stock are bought and sold through stock exchanges, although stock is also sold through local dealers in most large cities.

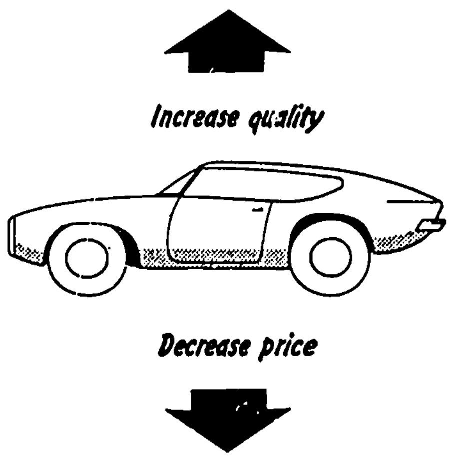


Fig. 7-10. Profits may be increased by increasing the quality of the product so that more people will want to purchase it. Likewise, if the company can decrease the price of the product by making it more efficiently and at less cost, the public is more likely to buy it.

low, Fig. 7-10. A decrease or increase in the price of raw materials or in wages may raise or lower costs. A change in price, supply, or demand may also raise or lower costs. Effective advertising or an unusual situation such as a war may increase the *consumption* (use) of a manufacturer's product. In fact, there are so many different factors that affect profit that it is impossible to list them all, Fig. 7-11. Their influence, however, is very important because companies constantly try to make a profit by giving the buyer higher quality goods and lower prices. Because companies try to keep their efficient, skilled employees through good treatment, fair wages, and fringe benefits, employees also benefit. Because management plans carefully for future profits in order to protect capital investments, investors also benefit.

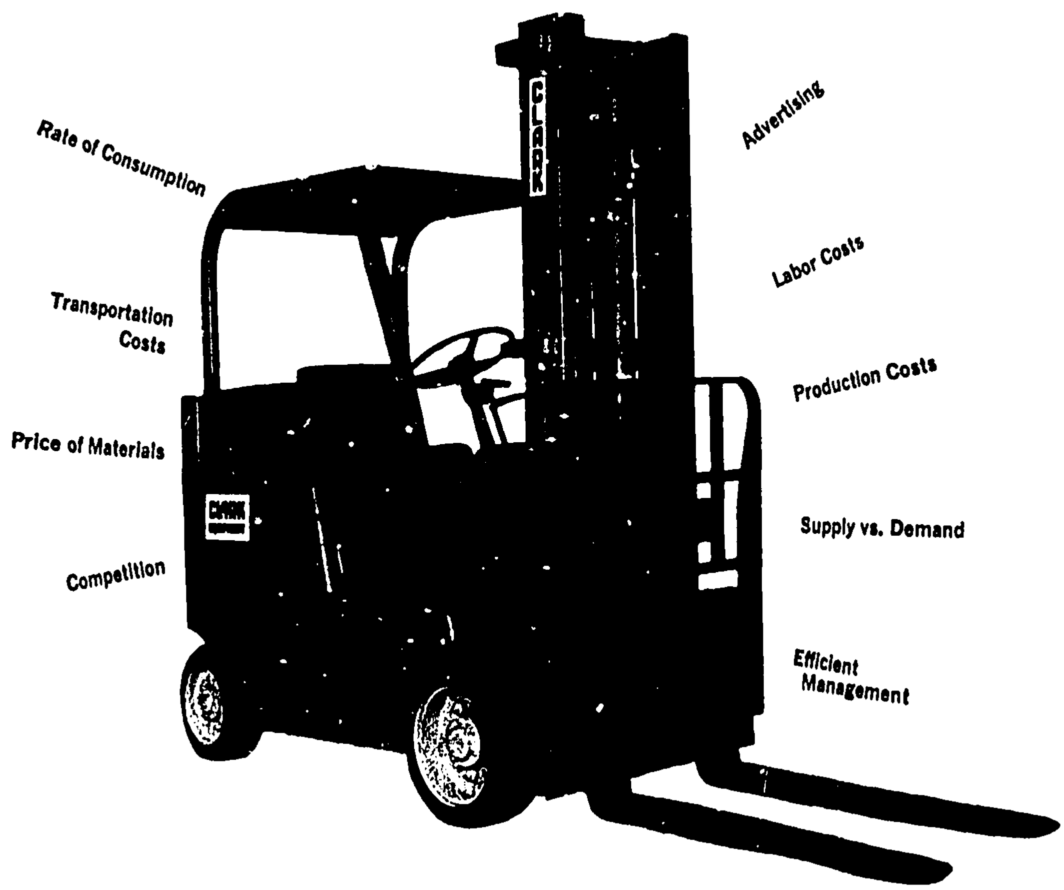


Fig. 7-11. Many factors affect the price of a product. Each of these factors seen here, and other ones not mentioned, must be thought of in planning the production of manufactured goods.

Summary

The main idea of the free enterprise system is economic freedom. Freedom has led to the growth of many kinds of manufacturing ownership (proprietorships, partnerships, corporations). Freedom has also led to the setting of prices and profit by competition. Government rules guide the free enterprise system in the public interest, Fig. 7-12. The American public has benefited because companies try to work as efficiently and fairly as possible in order to make a profit.

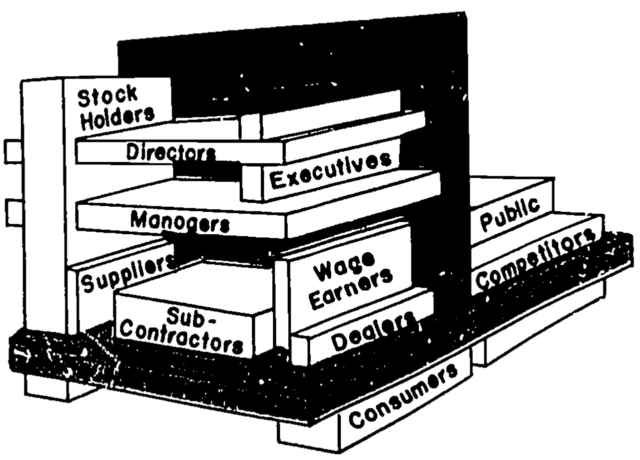


Fig. 7-12. The modern corporation consists of many parts. Each of these parts is necessary for the efficient operation of the whole. If one of the parts fails to perform as planned, all of the other parts are affected.

Terms to Know

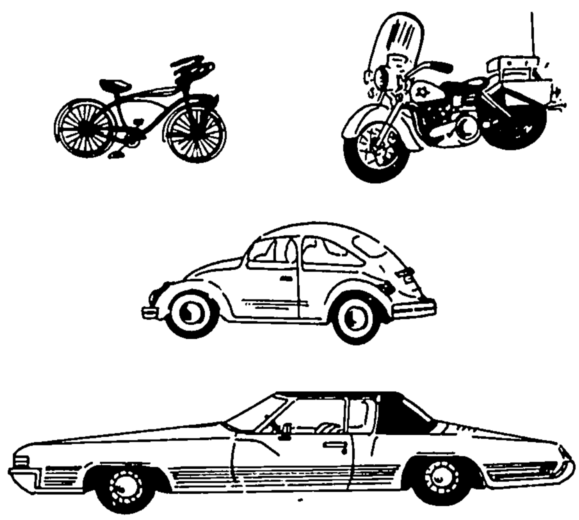
ownership
proprietorship
partnership
legal entity
corporation
liable
dissolve
debts
partners
amass
artificial man
charter
stock
stockholders
shares
stock certificate
mutual agreements
holding company
interlocking directorates
merger
consumers
business combination
horizontal combinations
vertical combinations
conglomerate combinations
board of directors
annual meeting
voting by proxy
dividends
preferred stock
common stock
lender
bond
bondholders
interest
fixed return from investment
stock market
profit
competitors
standard price
monopolies (trusts)
antitrust laws
regulates
public utility
factors
consumption

Think About It!

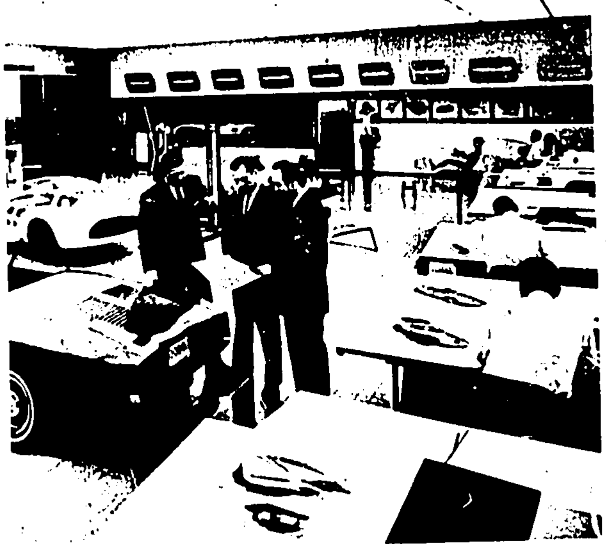
1. How would your life change if the federal government removed all regulations of public utilities?
2. If you were going to start a company, would you prefer it to be a proprietorship, partnership, or corporation? Why?

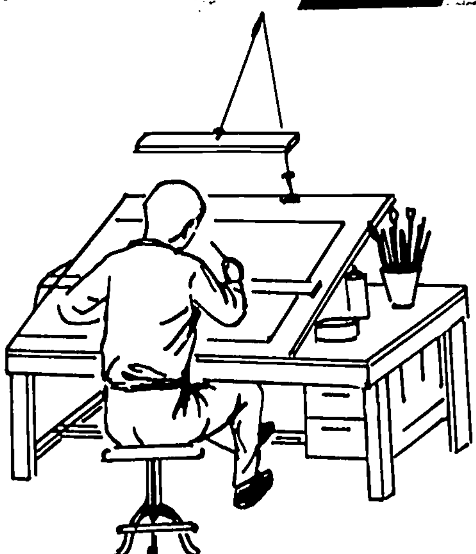
Man Plans,

Identifying Consumer Demands

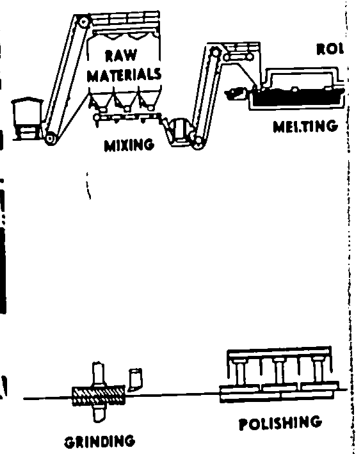


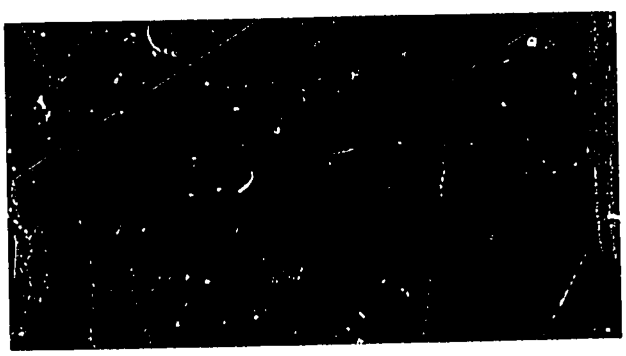
Designing Manufactured Goods





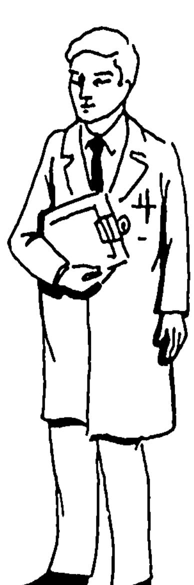
Planning



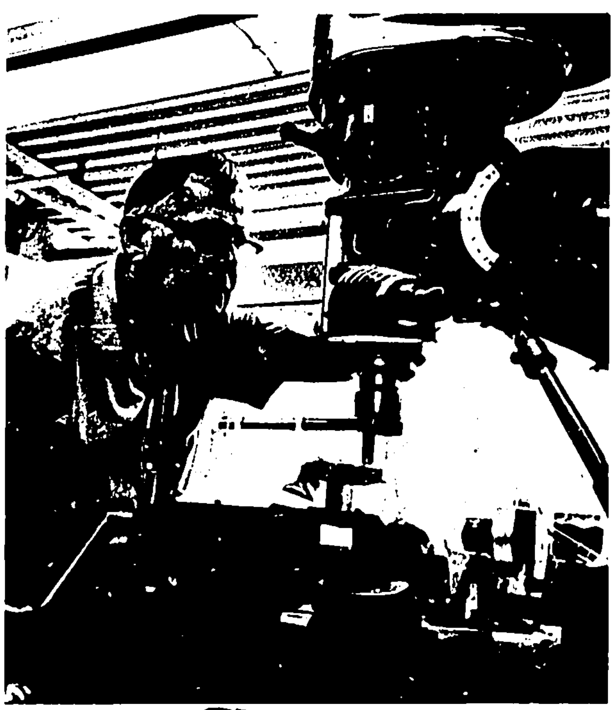


. . Organizes, ... and Controls Production

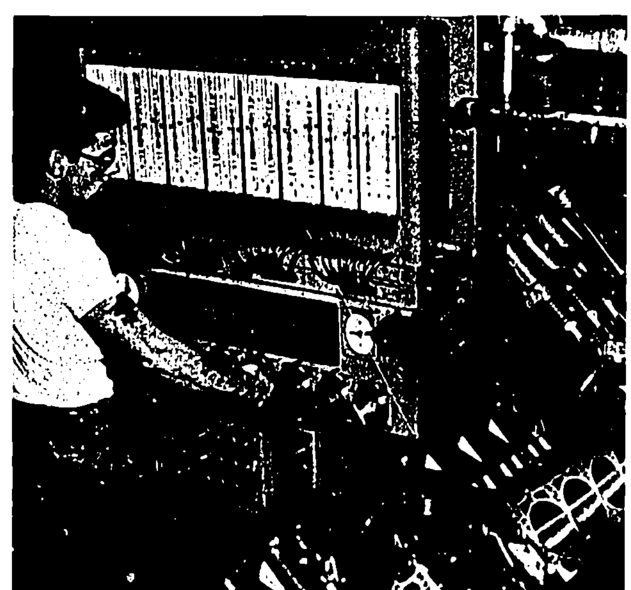
Production



Tooling Up for Production



Establishing Production Control Systems



READING 8

Identifying Consumer Demands

You have read what our manufacturing system is like, how it is owned, how it is organized to work, and the importance of profit. The system produces goods or services for which there is consumer demand.

Fig. 8-1. Consumers may be people who have special demands. This astronaut depends on this manufactured product to keep him alive in outer space.

For the system to make a profit, there must be *output* as well as *input*. Output is the product or service to be sold by a manufacturer. *Consumers* are the people or companies that will buy it. Since there are many different consumers with many different demands, the manufacturer must decide what output he will offer, Fig. 8-1. To do this, he must find out what the consumer will buy and at what price, whether there will be competition from other producers, and what this will mean.

In this reading, you will learn how manufacturers answer these questions about *consumer demand.*

Kinds of Consumers

Since a consumer is anyone who uses a product or service, all people are consumers. *Organizations* are also consumers, Fig. 8-2. They buy raw materials, finished products, and special services in their own line of work. Organizations include:

1. *manufacturers,*
2. *constructors,*
3. *retailers* and *wholesalers,*
4. *institutions* (such as schools and hospitals), and
5. the *government.*

Consumer Demands

Consumers want or need various products and services. If you think about it, wanting and needing are not the same, Fig. 8-3. For example, housewives may *want* a stove with

a fancy control panel, an electric clock, and a glass door on the oven. They may actually *need* only a plain stove that cooks. There is a demand for both plain and fancy stoves. Demands change. Consumers may decide that they want something today that they didn't want yesterday. This may happen because their standards of living change, or because a new kind of product is made. For example, years ago women were satisfied to wash the family clothes by scrubbing them with laundry soap. When automatic washers and synthetic detergents (man-made soaps) were introduced, women found out that there was a better way to do the wash. Permanent-press clothing has been developed because women want to cut down on their ironing. Contact lenses were made because people wanted their eyes to seem more natural. The desire for automobile safety has led to interior padding, tubeless tires, and safety belts.

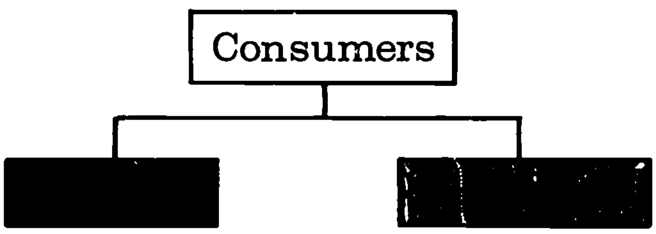


Fig. 8-2. Consumers are of two kinds: individuals and organizations.

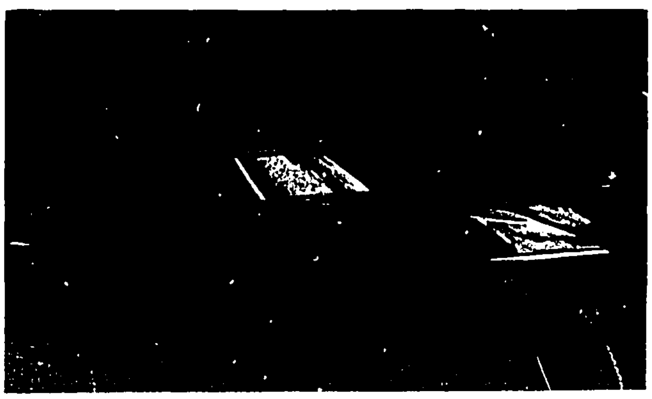


Fig. 8-3. The consumer needs transportation, but he *wants* cars such as this sport coupe.

Usually, if new product prices are too high, most buyers will wait until prices go down. This is the case with color television sets.

Seven Important Demand Questions

Suppose that a manufacturer can develop enough manpower, equipment, raw materials, and know-how to manufacture a new product. He needs to know whether there is a demand for this product. If there is, he needs to know what the demands will be. To find out, the manufacturer asks these questions:

1. *What is the potential* (possible) *market for my product?* How many buyers will want or need the kind of product I offer?
2. *Who makes up this market?* Will the demand come from all kinds of people and organizations or from certain groups?
3. *What is the trend* (direction) *in sales for this market?* Is the market growing from year to year? Is it about the same from year to year, or is it declining?
4. *Will at least some buyers prefer my product to others they can buy?* Is the performance, packaging, and price of the product good enough to compete with other products?
5. *How will competition affect my product?* Will competition take away my business or increase the demand for my product?
6. *If there is competition, how many sales can I expect?* If I make widgets, will I sell 50% of all widgets bought or only 5%?
7. *Based on the share of market* (sales) *I expect, will the number of products sold be large enough to give me a profit?* Will probable sales pay me back for the money I've put into buildings and equipment? Will it also cover production and operating costs, leaving me something extra for profit?

If the answers to any of these questions are unsatisfactory, the manufacturer must consider redesigning his product or changing his plans to *market* (sell) it.

Obtaining Consumer Demand Information

Before marketing a product, a manufacturer can *research a market* (get facts to find out possible sales). After the product is placed for sale, close watch can be kept on the market to see how much buying and selling is being done. A manufacturer may *consult* (check) *available market data* (information already on hand), or he may do his own *specialized consumer research.* In the case of low-cost goods that can be made in large numbers, the manufacturer may make a small number of products and let people actually test them. For high-cost, long-lasting goods, he may use information already on hand for similar goods.

Available market data are of two kinds: (1) *surveys* made by government or by private firms, such as U. S. Census or magazine surveys of special markets (for example, "What Are Teenagers Buying Today?"), or published studies of sales; and (2) *market performance data* (sales information) usually bought from research firms. For instance, the A. C. Nielsen Co. reports the monthly or bimonthly sales figures on leading brands of products for all areas of the country. After sales have started, a manufacturer can check his own sales and shipment figures.

Specialized consumer research includes these studies:

1. *Usage and attitude research*—asking questions through interviews and questionnaires about consumer buying habits, buyers' attitudes toward current products, and their desires for product improvements;
2. *Product research*—gathering consumer opinions on product performance, package designs, brand names, and product appearance, Fig. 8-4; and
3. *Advertising and promotion research*—checking how many consumers are likely to remember a television commercial or an advertising slogan, or to be attracted to a store display.

Studies can be made to find out consumer response to everything from a price change to a coupon mailing. Usually, the producer can do research in his own market research department, or have it done by an advertising agency or private market research firm.

Marketing the Product

When a producer knows he can make a product and that there is a demand for it, he draws up a *marketing plan* that shows how the product will be sold. The plan uses the information and *strategy* (plan of action) for sales, promotion, and advertising. The plan shows:

Fig. 8-4. This market research interviewer is asking questions to find out consumer opinions and attitudes toward products and advertising.

1. Purpose or purposes for which the product is to be sold.
2. Sources from which sales are expected.
3. Kinds of people who will buy the product.
4. How they buy and how often.
5. Price and value information.
6. *Product performance* (how well it works) and advantages to be pointed out in advertising.
7. Kind of advertising (newspapers, radio, TV).
8. Ways of *distribution* (ways of getting the product to the buyer).

Distribution can be through a wholesaler or a retailer, or the product can be sold directly to the customer, Fig. 8-5. For production purposes, the manufacturer will also make a *sales forecast* (estimating sales from month to month and area to area).

When a product is being sold, the producer must decide how to make his product *more* acceptable to consumers. This can be done by improving the product, lowering the cost, and providing better service. The producer who does not do these things will find his sales falling as competitors improve *their* products.

A lot of time can pass between finding out buyers' wants and marketing the product. Sometimes ten years or more may pass. In other cases, products are put on the market in just a few months.

Summary

We have seen that consumers are people or companies that use products and services. Consumer demand is based on the needs and wants of a consumer group, Fig. 8-6. As living standards change or as new products are made, wants and needs also change. Before a producer decides to make a product, he must make sure that there is a demand for it. He must find out the probable size and the condition of his market. He must figure out how many buyers will want his product. He must decide if the likely number of sales will give him a profit after costs are paid. To answer these questions, the producer can use market information on hand or he can do his own research. When he thinks his product can be sold for a profit, he makes up a marketing plan showing the information and strategy needed to sell his product.

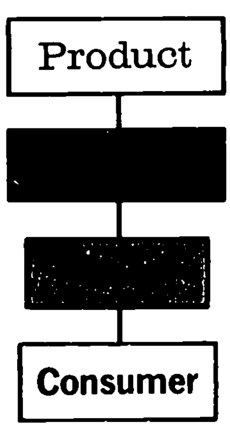


Fig. 8-5. A marketing plan shows how the product will be sold. The ways of distribution may be different for different products.

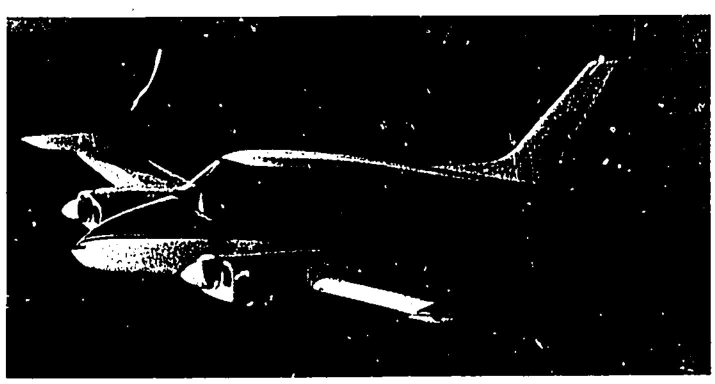
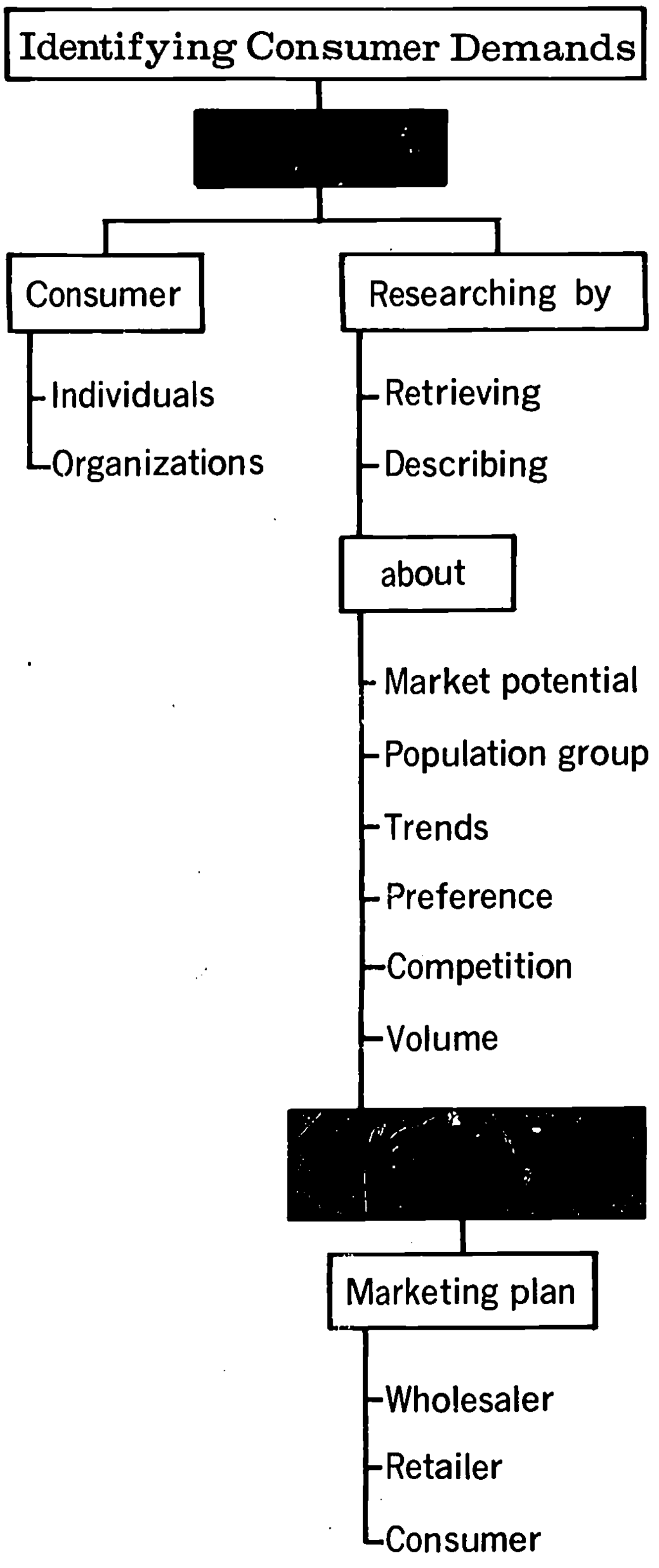


Fig. 8-6. Consumer demands vary according to the use to which the product will be put. For example, individuals may want aircraft for private use. Airlines use aircraft to carry passengers. The military use aircraft to defend the nation.

Terms to Know

output
input
consumers
consumer demand
organizations
manufacturers
constructors
retailers
wholesalers
institutions
government
potential
trend
competition
share of market
market (sell)
research a market
consult
available market data
specialized consumer research
surveys
market performance data
usage and attitude research
product research
advertising and promotion research
marketing plan
strategy
product performance
distribution
sales forecast



Think About It!

1. If you (or any member of your family) found a product that you really did not like, how would you go about informing the manufacturer of your dislike?

2. Ask your parents if they have ever been questioned in a consumer survey. If they have, was it by interview or by questionnaire? At home or in a store?

Researching and Developing

READING 9

This reading tells you about two of the most important activities in the manufacturing industry. These activities are *research* and *development.* For short, they are often referred to as R&D. You will learn about where and how they are done and about the interests and abilities of the people who do them.

Research (seeking more knowledge) and *development* (putting the new knowledge to work) are usually done for one or more of three reasons. These are:

1. To satisfy man's wish to understand his physical surroundings,
2. To add to the knowledge needed to solve problems important to man's health and safety, and
3. To invent processes or products to satisfy man's wants and needs.

Research and Development Defined

Research and development in manufacturing produce *new knowledge* and *new* (or improved) *processes or products* for the manufacturers. However, this new information is seldom really new. It may have been thought of or tried out many years ago. At that time, men may not have had enough other knowledge, processes, or products to develop and use this new information. *Advances* (progress) made by research and development always depend on earlier attempts to solve the problems of manufacturers.

In manufacturing, research and development go on all the time. They are a part of every step of manufacturing—those steps you have already read about and those you will study later.

Kinds of Research and Development

Research and development may be broken down into many different activities. They are easily thought of, however, as being made up of basic research, applied research, and development.

Research is the process of retrieving (collecting), describing, and experimenting in order to develop or discover new knowledge. When it is done mainly in order to add to man's knowledge, it is called *basic research,* Fig. 9-1. Basic research, then, is not usually concerned with whether the new knowledge will or can be put to any use, now or later. Basic research is sometimes called *pure research.* For example, you would be doing basic research if you were looking for the main causes of friction when one solid body is slid along another. The research would

Fig. 9-1. Pure (basic) research is carried on in search of new knowledge.

be basic so long as you did this mainly in order to understand the causes of friction. If you did it mainly in order to learn how to improve sliding bearings in machines, you would be doing *applied research.* Applied research is research done mainly to produce knowledge which can be put to work, Fig. 9-2.

Development is the work of designing and engineering new or improved processes or products by using research findings and other knowledge, Fig. 9-3. An example of development would be using the findings from your basic or applied research to make a very low-friction sliding bearing for use in a machine. You would first become familiar with existing kinds of bearings and the results of other research on friction. Next, you would do some serious thinking about how all this knowledge could be used to make a better bearing. With these ideas you could build an *experimental* bearing of the kind you had imagined. You would test

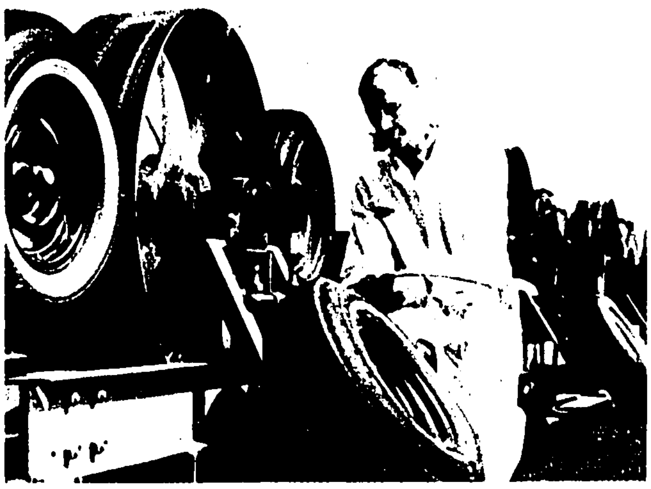


Fig. 9-2. Researching and developing is a nearly endless process for improving products.

Fig. 9-3. Development testing of a polyethylene film may be carried out by using a sandbag drop test.

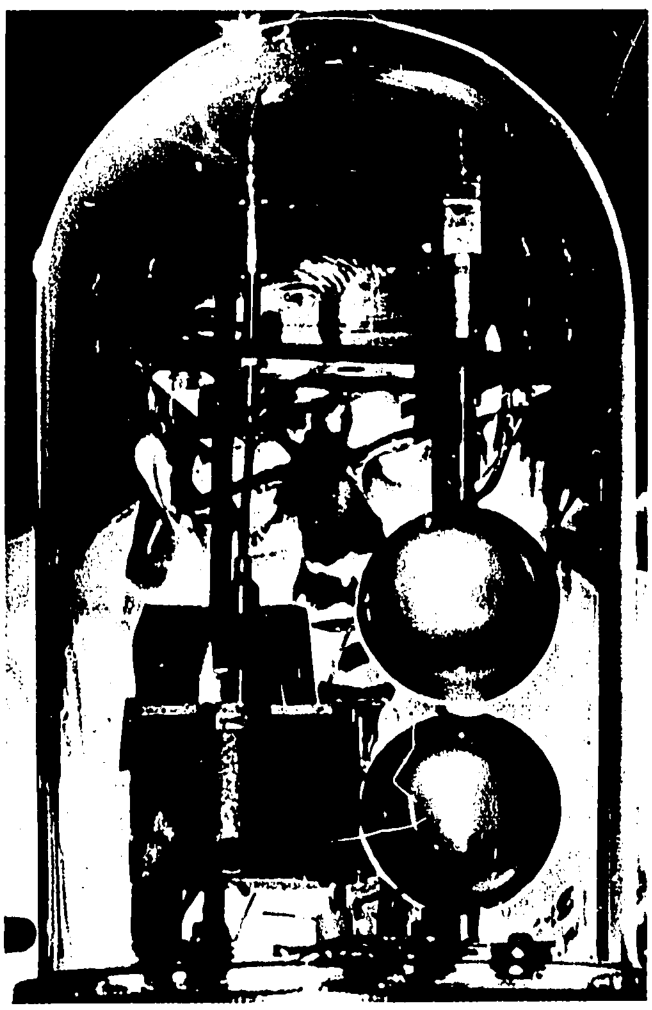


Fig. 9-4. Research data must be gotten carefully to insure accuracy. This experimenter is simulating a space atmosphere in a bell jar.

it by comparing it to the best existing kind of bearing. In this way you would find out if it was better than, or as good as, the existing bearing. If it is not, you would repeat these processes again and again, benefiting by the knowledge gained from your failures, until you did arrive at a better bearing. Or, you might finally learn that you need more new knowledge about friction to solve the problem. Then you would return to more researching. After gaining new knowledge, you would return to more development.

Importance of Research and Development

Research and development are the most important sources of industry's new knowledge, processes, and products. They are key parts in keeping industry going and growing, Fig. 9-4. They have given us almost all of the new products, processes, and materials which did not exist when your parents were born. The importance of research and development becomes clearer each year. In the United States during 1970, about $20 billion was spent for research and development. This accounted for over 2 percent of the gross national product. Research and development have really grown since 1951 when less than $3 billion was spent. Over this same period of time, national defense is the only other part of the economy that has grown as rapidly.

People and Organizations in Research and Development

The research and development activities important to industry are carried on by many people and organizations. In industry, almost one million people directly carry out research. Many *private* and *public research and development firms* also serve industry either directly or indirectly.

Private or *university-linked research firms* do research and development work on a *contract* (agreement) *basis* for industry. In some branches of industry, companies join together to do research on common problems, Fig. 9-5. Universities across the nation have been a major source of research and development for industry. Universities, for example, have been leaders in such R&D areas as nuclear fission, atomic structure, and high-speed computers.

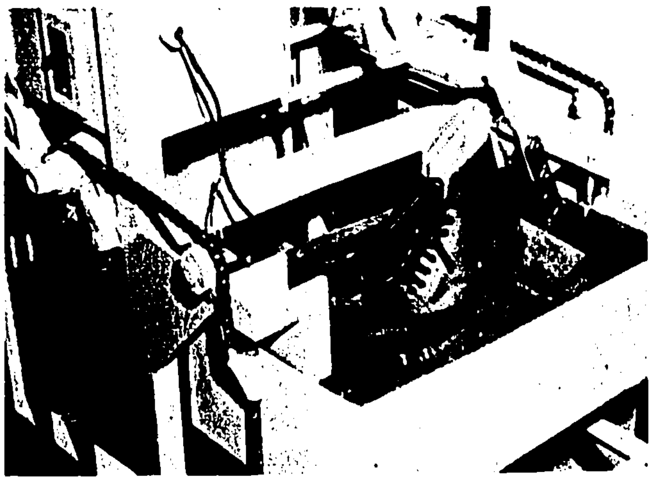


Fig. 9-5. Research knowledge may be gotten from development testing. This work shoe is tested for water resistance.

Fig. 9-6. Experimenting with very low temperatures, man has found metals can be tested at lower than −400°F.

Many government agencies *sponsor* (support with money) research and development. The Atomic Energy Commission, the National Aeronautics and Space Administration (NASA), and the Department of Defense are examples of such agencies. They also carry out research and development on their own. The results of these R&D activities are often useful to industry.

Foundations encourage and support research. These are *trusts* and great funds created by public-spirited men and women or the U. S. government. They do not carry on research themselves, but instead support it with money. Most foundations support basic research, Fig. 9-6.

The people who carry out research and development need to have a broad knowledge of science and technology. They also need to be able to *adapt* (adjust) to change. Usually they should have formal training or education in science, technology, and mathematics. They should also have a high degree of curiosity, readiness to work, leadership, and ability to express themselves. Job opportunities in the field far outnumber the supply of trained people.

Doing Research and Development

The main kinds of research are *retrieving, describing,* and *experimenting.* In each case, the researcher tries to solve a problem.

In *retrieving,* the researcher collects information related to the new knowledge needed. Information is found in books or journals, research reports, and other literature and objects found in libraries or research laboratories, Fig. 9-7. Retrieving helps the researcher answer the question, "What is already known about the problem?"

Describing helps the researcher to answer the question, "What is?" Describing provides knowledge of the nature or *features* (characteristics) of materials, processes, or products, Fig. 9-8. In the last reading, you learned about market research. When the researcher asks the consumer questions, he is trying to describe what products people want and need. Research on strengths or hardnesses of new materials is another kind of describing.

Fig. 9-7. Knowledge is retrieved from many sources. This researcher is preparing to read microfilm.

Fig. 9-8. The man at the control panel is describing the characteristics of the natural gas being tested.

Experimenting answers the question, "What will happen if I change some factors and do not change other factors?" Experiments are very common in research. Suppose that you are the manufacturer of a floor wax. You want to find how it will wear, coat, and protect a certain kind of floor. You set up an experiment by subjecting the wax to different kinds of wear. You may even wish to compare your wax with that of a competitor. You might *simulate* (imitate) wet or dusty conditions to see which wax will perform better.

In all research, you develop *hypotheses* (hunches) about the possible answers. Then you collect *data* (evidence) and compare the evidence with your hypotheses. Then you draw *conclusions*. This provides new knowledge. If you have not found the answers you need, you develop new hypotheses and repeat the process. This process goes on as many times as are needed to solve your research problem.

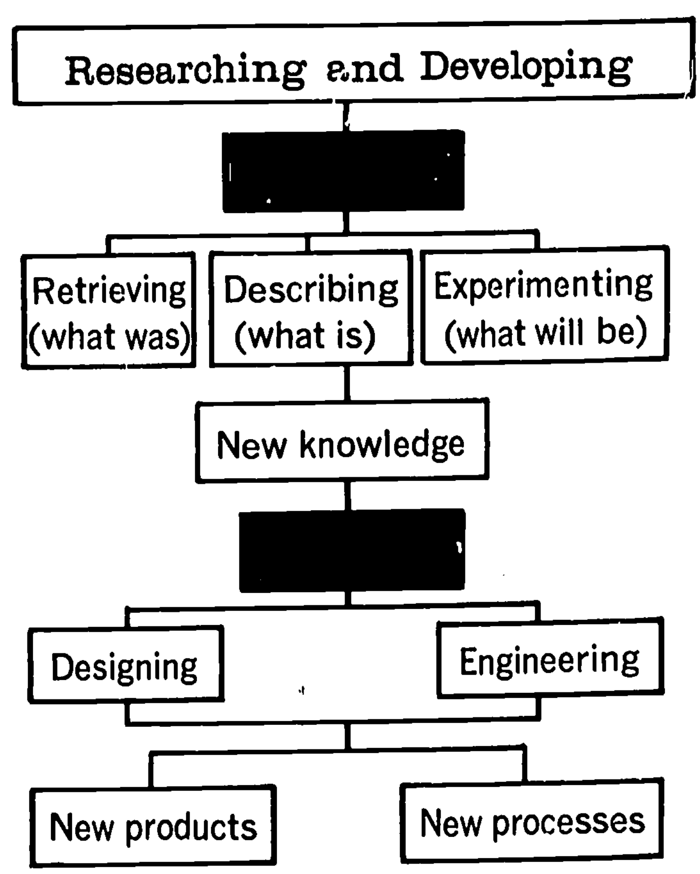
In *development*, the steps are about the same. But what is now desired is a new or improved process or product to meet particular needs. First, you gather and study information related to the new process or product from many sources, especially the results of other research. Then, you develop hypotheses about the features the new process or product should have to meet the particular needs. The next step is to make *sketches* and *drawings*. A *prototype* (working model) of the desired new or improved process or product is usually built. Finally, you test the model to find out whether it actually meets the needs. If so, the research and development job is done, and the process or product can be made ready for production. If not, the knowledge gained from the developmental prototype is added to your previous store of knowledge, and you repeat the process.

Summary

Research and development work in manufacturing produces new knowledge and new or improved processes or products for the manufacturing industry. They are processes which go on all the time.

The research and development activities important to industry are carried on by many people and organizations. These include industry's own research people, private research firms, universities, government agencies, and foundations. People who work in research and development need a broad knowledge of science, technology, and mathematics. They should have a high degree of curiosity, readiness to work, leadership, and ability to express themselves.

Research is the process of retrieving, describing, and experimenting in order to develop or discover new knowledge. It may be called either basic research or applied research, depending on its aims. Development is the process of designing and engineering new or improved processes or products by using findings from research and other knowledge.



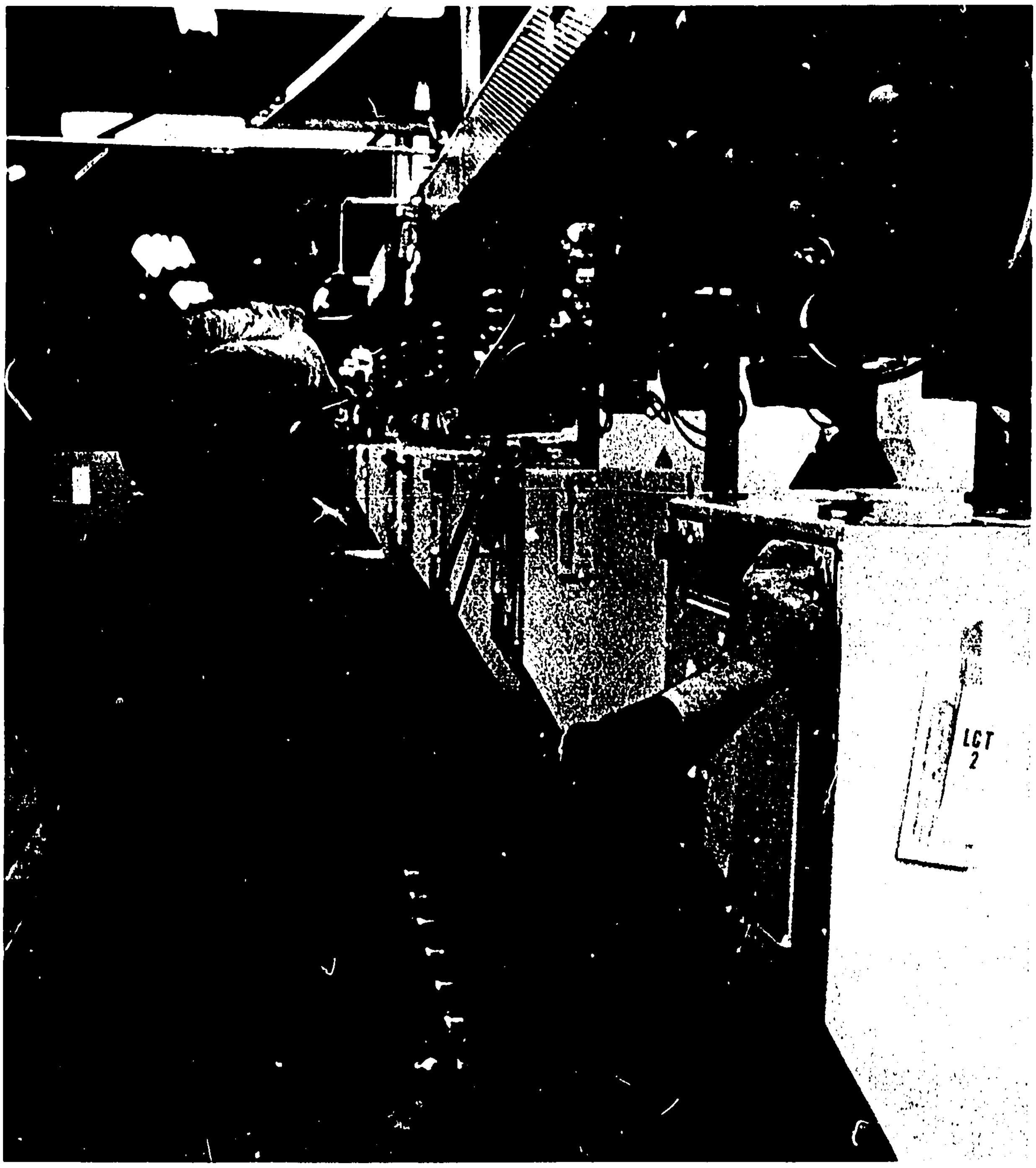
The first step in carrying out research and development on a problem is to collect and study the existing information about the problem. Hypotheses about possible solutions to the problem are then developed. These are tested in many ways. If the results *confirm* (agree with) the hypotheses, the problem is solved. If not, the process is repeated until a solution is found.

Think About It!

1. What kinds of R&D work would go on in the major automobile manufacturing companies?
2. R&D work is expensive and does not always result in usable knowledge or products. In what ways have its results more than paid for its costs?

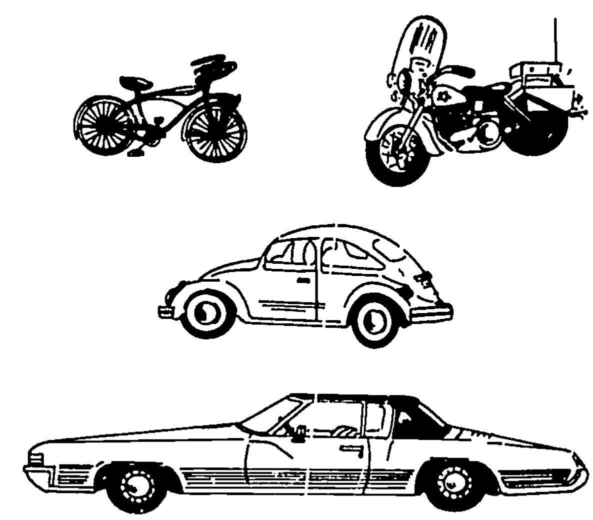
Terms to Know

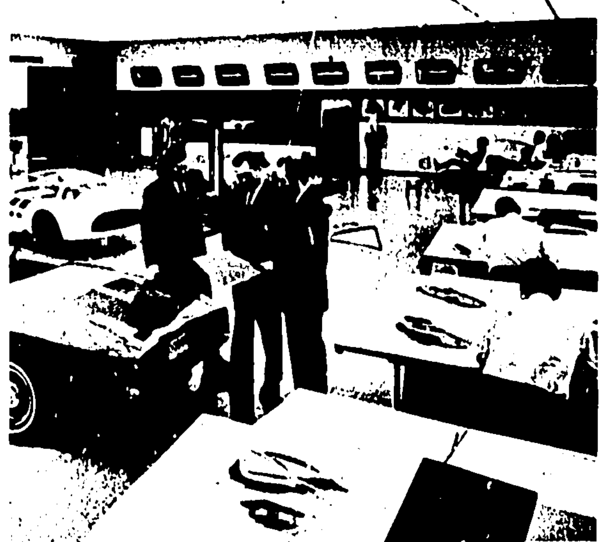
researching	contract basis	applied research	data
a. retrieving	sponsor	experimental	conclusions
b. describing	foundations	private research and development firms	sketches
c. experimenting	trusts	university-linked research and development firms	drawings
developing	adapt	public research and development firms	prototype
a. designing	features		confirm
b. engineering	simulate		
basic (pure) research	hypotheses		

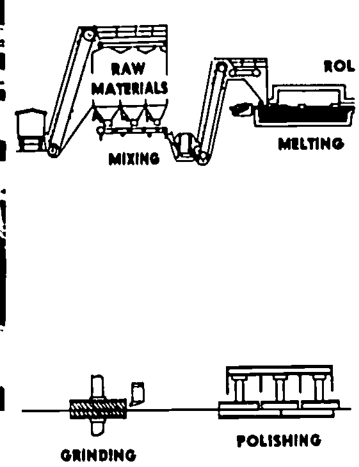


74

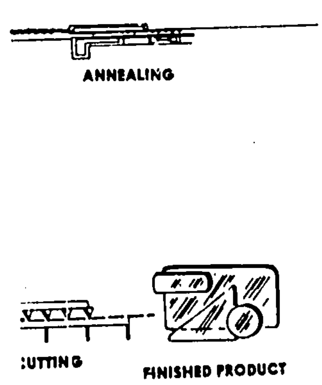
Man Plans, ...

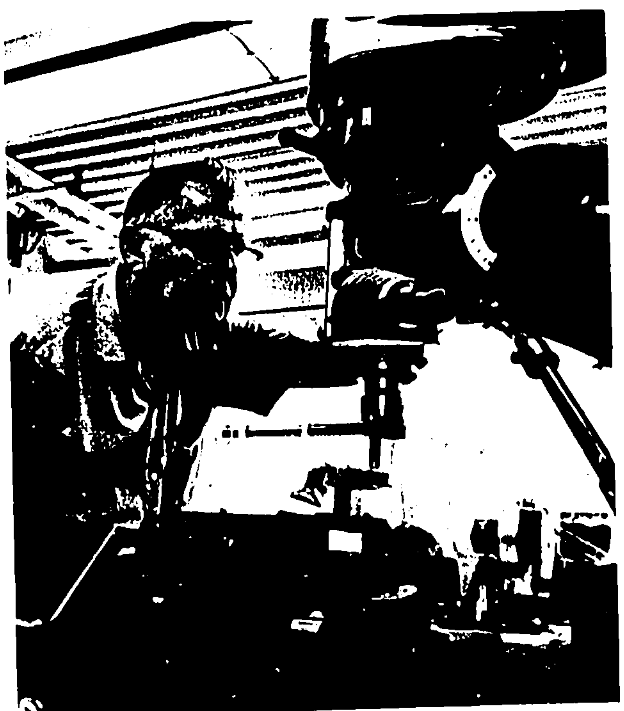


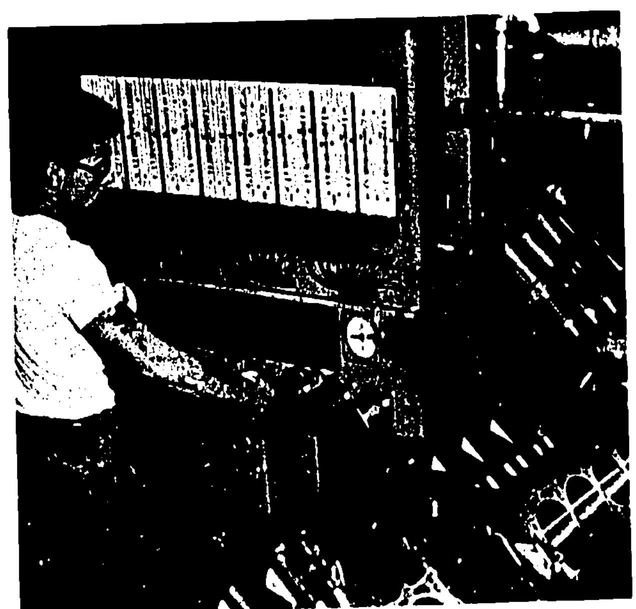


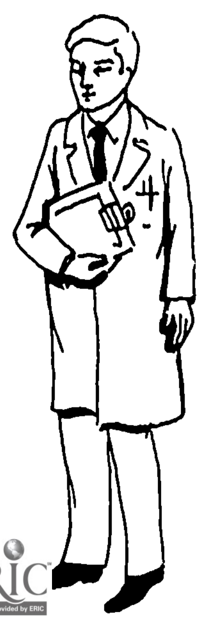


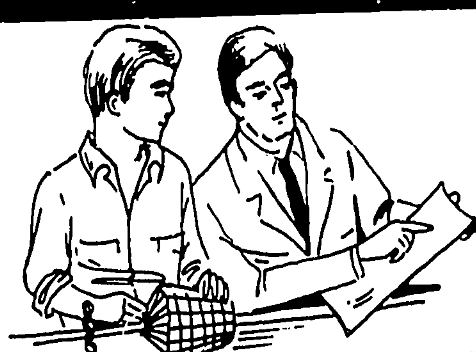
. . Organizes, ... and Controls Production

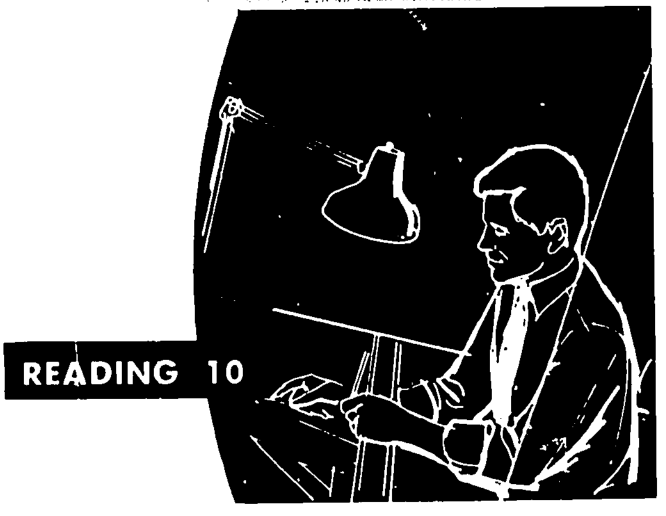












READING 10

Designing Manufactured Goods

In manufacturing, *designing* means to create plans for products and systems so that they will be attractive and will *perform* (do) well the tasks they are supposed to do. Designers want to create products and systems which will be accepted by customers, Fig. 10-1. They try to create products which will give real service.

All manufactured products are designed *before* they are produced. Some products are designed by the owner of a small shop. Other products are designed by workers in the shop, by draftsmen, or by engineers.

Today, design is done more often by specialists trained in product design *principles* (rules). No matter who does the designing, the same steps are followed. In this reading, we will look at product designing as it is done by *product design specialists* in manufacturing.

Fig. 10-1. Management must make sure of enough sales before asking for new designs.

Industrial Design

After management has decided that a certain product is to be made, two groups of people are most important in the early *phases* (steps) of its development. These groups are:

1. *Product designers* (industrial designers), and
2. *Product engineers* and *manufacturing engineers.*

Industrial designing is product designing for industry. Product designing deals with *appearance* and *function.* Appearance is more than how pleasing the product looks. It is what the customer will buy and how well it suits the product function. Function means how well the product does what it is supposed to do.

The designer must think about safety, ease of *maintenance* (upkeep), ease of use, ability to be produced, and cost. When he designs industrial equipment, he must think carefully about its safety and ease of maintenance. But he still wants the product to look as if it will do the job it is supposed to do and to be pleasing to look at, Fig. 10-2. When the designer designs a consumer product such as a lighting fixture, its pleasing appearance must be thought about as well as its safety. This does not mean that lighting efficiency will be given up. It means that in making design decisions, appearance is thought to be just as important as efficiency.

All products require product design. Whether the design is good or bad, it comes about through the efforts of one or more people. Some products do not give the designer much chance for *visual design,* Fig. 10-3. Gasoline is an example. If, however, we

think of the many product designs necessary for its sale (like signs, service stations, and pumps), we see that gasoline does need product design. All the major oil companies employ industrial designers to design their stations, equipment, and product packaging, Fig. 10-4. Designers have even designed cookie shapes for bakeries.

In the case of *custom-made* (made to order) products, the designer is also needed. A good example is the designing of airplane interiors. Many companies that own their own airplanes have the interiors custom-made. Again, *all products must be designed.* When trained specialists do the designing, all parts of the design are sure to be thought about.

Consultant and Corporate Designers

Product designers (industrial designers) are of two kinds: (1) *corporate designers,* and (2) *consultant designers*. Both have the same educational and professional backgrounds. Designers often change from one group to the other. The corporate designer works for the company for which he designs. The consultant designer works in an office that provides product design for many

Fig. 10-3. Some designs are hidden in the product.

Fig. 10-2. Buyers may have personal preferences and must be given a choice. Appearance may be very important.

Fig. 10-4. Packaging must be designed. For many products, the buyer sees only the package.

clients (customers). Corporate designers often hire consultant designers, either to give them new ideas or to help them out when there is too much work to do.

Consultant design offices give the designers many kinds of products to work on. Corporate designing does not have this variety, but it does give the designer more complete control of design details since he can work with his design from the idea to its production, Fig. 10-5.

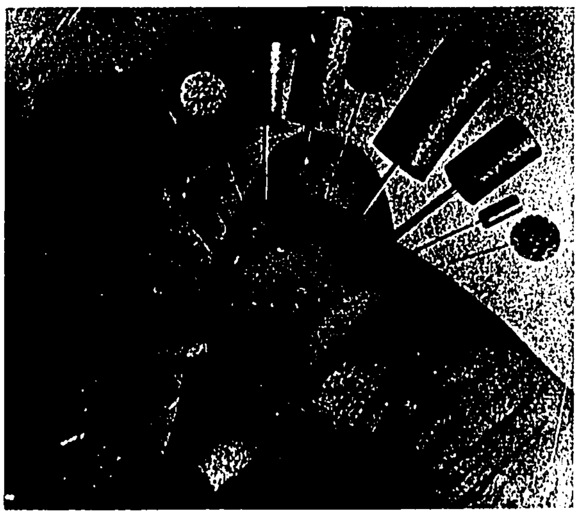


Fig. 10-5. Many kinds and sizes of parts are needed for the exact job to be done by capacitors.

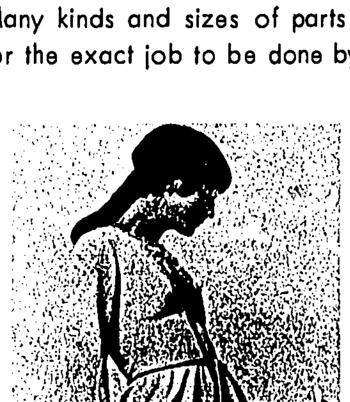


Fig. 10-6. Styling may be the most important part of designing.

Today, more and more corporate designers are being hired because product design is necessary to the success of any product, Fig. 10-6. Within a corporation, design is a part of the planning function of management. Many large companies have designing directors on their staff. These designers are a part of the top decision-making team. Usually, if a company needs industrial design all the time, it saves money by having its own corporate designing office. If there is no need for design work all the time, the company saves more money by using a consulting office.

Product Designing Procedures

All product designing follows a similar pattern. A design usually starts with a new idea. One of the jobs of product designers is to create new ideas (*concepts*). Concepts are thought of in many ways—sometimes from inventions, sometimes by accident. It is the designer's mind, however, that sees the possibilities of a concept (idea).

Research by a designer can bring out a new concept. For example, if a designer decides to look for ways to satisfy personal care needs, he might come up with an electric toothbrush, a hair dryer, or an electric clothes brush. Once the idea of the product is fixed in his mind, the designer can start thinking about ways to solve his problem. First, he does research. This means finding all the information he can about what the product should do. This could include surveys, personal experience, and talking to people who might have knowledge about the product. If the designer is designing an electric toothbrush, he will talk to dentists.

As soon as the designer feels that he has enough knowledge and information about the product, he will start sketching his ideas on paper, Fig. 10-7. These sketches are used mainly by the designer to help him *formulate* (express) his thinking. It is also easier

to discuss details with others if you have a sketch to help explain your ideas.

The designer next makes a rough cardboard or clay model of the product. This helps him with the *functional* part of the design (how useful it will be). For example, if he is designing an iron he wants to try different handle shapes to see which is the most comfortable. If he is designing the operator's station of a power shovel he wants to make sure the seat and controls are in the best place for smooth and easy operation.

Once the *basic form* and *dimensions* (sizes) are decided on, the designer continues to sketch as he works out new *refinements* (improvements) and additions. Throughout this process the designer is solving problems of making the product easy to use, easy to manufacture, and inexpensive to make. The product should also have a pleasing appearance. The designer makes sure his activities and decisions fit those of the manufacturing engineering department, Fig. 10-8. *Producibility* (ability to be produced) is important in any design problem.

When the design solution is complete, the designer makes a careful sketch of the product. This is called a *rendering* (an exact picture of the design solution). This rendering may then be used in a *presentation* to top management. Most designers, however, prefer to use models for presentations because some people have trouble seeing the product in their minds from a rendering, Fig. 10-9.

The designer himself usually does not make the *three-dimensional models*. He makes drawings from which trained specialists build the models. These same drawings are given to the engineers who then use them as guides in making the *production drawings*.

After the models are made and the design solution is accepted, the designer's job is not over. He works with engineering and production people to make sure the changes needed

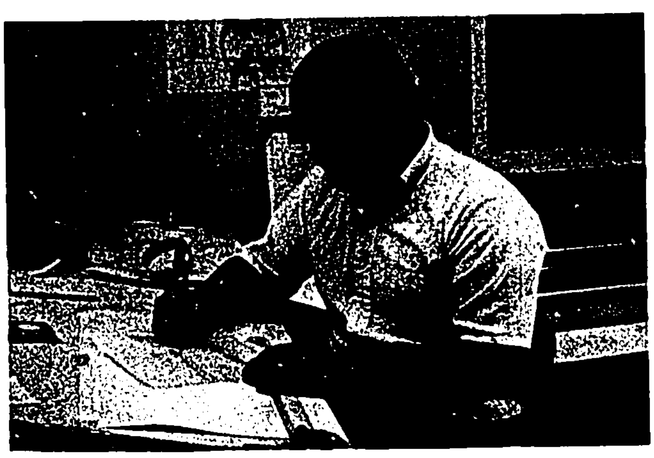


Fig. 10-7. The designer starts with sketches.

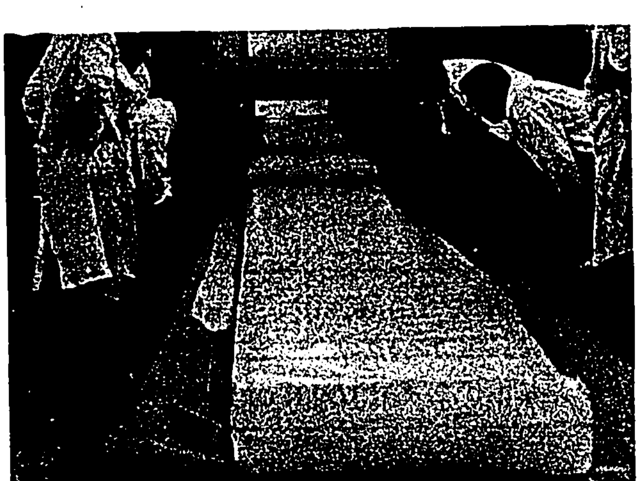


Fig. 10-8. Designers consult with engineers and production personnel. Future problems may be avoided by design conferences.

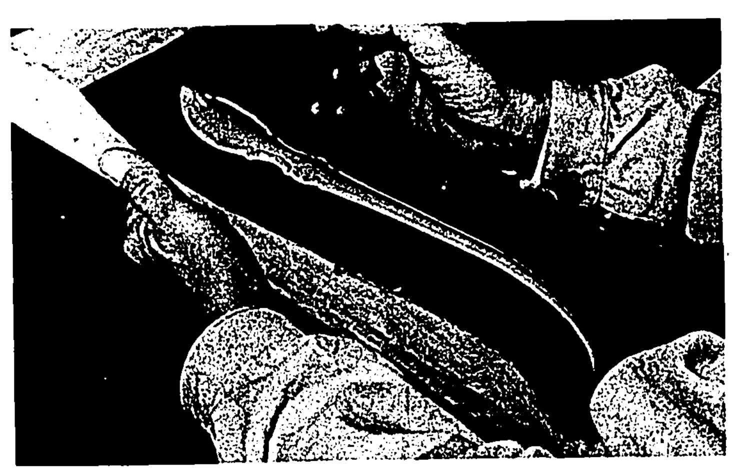


Fig. 10-9. After sketches and preliminary drawings have been made, a three-dimensional model of a handle for silverware is made for presentation to management.

in order to make the product do not change his basic design concept, Fig. 10-10.

Fig. 10-10. The designer must continue to work with engineering and production personnel through final assembly.

Summary

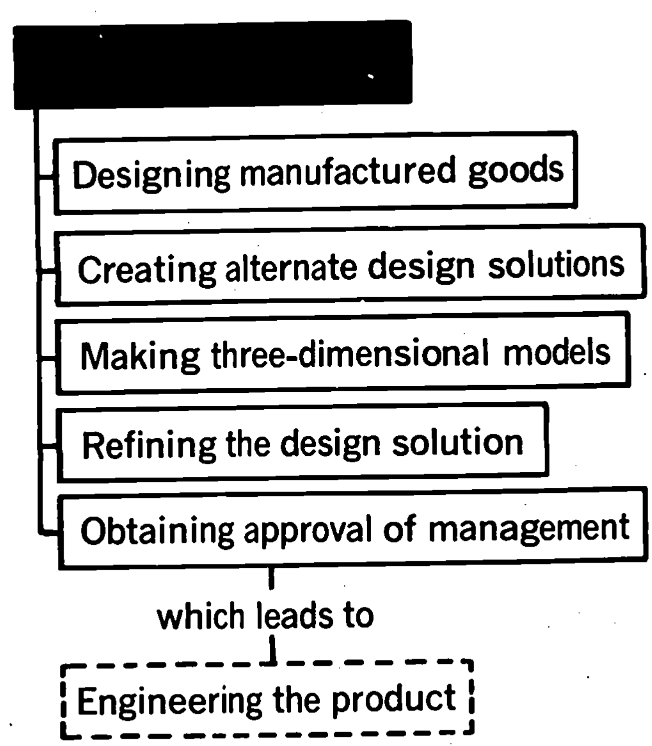
All products must be designed. Product designers and engineers bring a design through the development process. A product designer (industrial designer) is a trained specialist. His talent, training, and experience should result in good solutions to design problems. There are two kinds of product designers: those who work for a company and those who work in a consulting office. Today, greater numbers of corporate designers are being hired but both groups do the same kind of work. The designer follows three steps to reach a design solution. First, he does research to become familiar with the design problem. Then, he starts the design with sketches and rough models. Finally, a finished model of his design is made and presented to top management for their decisions.

Terms to Know

designing
perform
principles
product design specialists
phases
product designers (industrial designers)
product engineers
manufacturing engineers
appearance
function
maintenance
visual design
custom-made
corporate designers
consultant designers
clients
concepts
formulate
functional
basic form
dimensions
refinements
producibility
rendering
presentation
three-dimensional models
production drawings

Think About It!

1. When you look at the latest model bicycles, which is more important to you—*appearance* or *function?* Why?
2. Figure 10-4 points out that buyers often see only the package, not the product. What products do you (or your family) buy even though you can see only the package?



READING 11

Creating Alternate Design Solutions

You have read about product designing and the work of the product (industrial) designer. Now you will learn in more detail about the methods used to come up with a final *design solution*. Once the product *concept* (idea) has been decided on, the designer takes two steps in *design development:* (1) *sketching*, and (2) *model making*. He has developed some tools to help him in each step.

Making Sketches

Sketches are one of the tools of product design. By making sketches the designers can study different ways to come up with a design solution. Sketches are cheap to make and can be done quickly.

Several kinds of sketches are often used. One is called a *thumbnail*. This is usually a small quick sketch, almost a doodle, that the designer uses to start his thinking. He does not show it to anyone except perhaps another designer. It is usually too incomplete for the average person to understand. Another kind of sketch is called a *rough*. This is a rough *representation* (picture) of the design, Fig. 11-1. It is done rather quickly and may have suggestions about color and material. The designer may make a large number of roughs. He will try out many possible shapes as well as different ways to *fabricate* (put together) and use materials, Fig. 11-2. Here again the designer will not wish to show these roughs to someone who is not a designer.

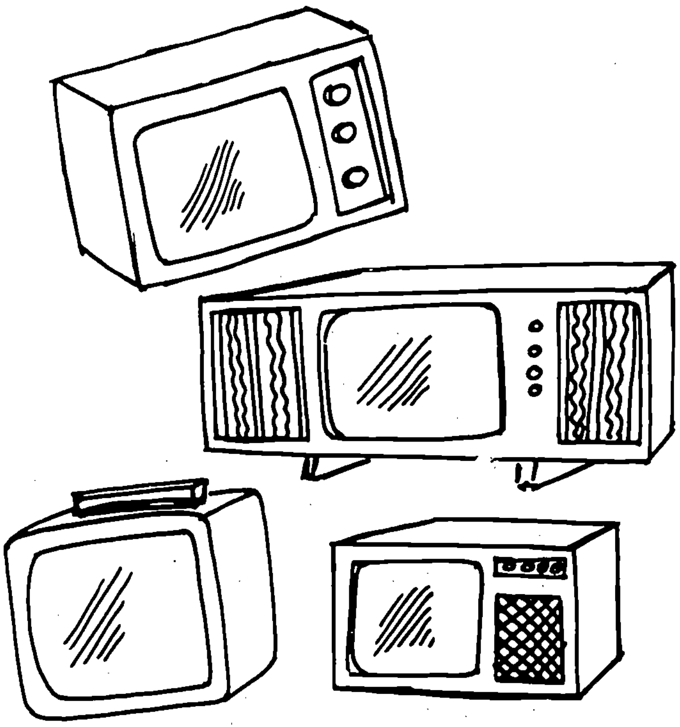


Fig. 11-1. Rough sketches are made by a designer to show many ideas.

Fig. 11-2. Sketching and modelmaking show different ways a product can be designed.

When he feels that enough ways have been tried out, the designer will pick (from his roughs) those designs he thinks can be used. He will make these *alternate* (possible) design solutions into sketches that people who are not designers can understand. These sketches can be used for *preliminary* (beginning) explanations of the product concept to top management and to engineering. The designer will also be ready to explain the *merits* (advantages) of each of these alternate designs. Now it is possible to think about *producibility* (the ability to produce the design), *tooling* (making machines ready for production), and *piece-cost estimates* (predictions of how much each piece will cost). As this information grows, the designer changes his thinking according to what he finds out from others. The design, of course, can still be changed, but now other people have a design to think about and work on.

There are many ways of sketching that the designer can use. Colored pencil, pastels, and felt-tip pens are widely used. Some designers use all three of these, as well as watercolor, in a single sketch. Most design offices do not ask for very detailed sketches. What they want is a quick sketch that tells the story simply. When final *presentation* (explanation) is made, a very careful sketch is made. This kind of sketch is called a *rendering*, Fig. 11-3. Renderings were once widely used. In many design offices, a rendering specialist did all the renderings for that office. Most designers now feel that sketches give an incomplete picture of the design solution, so the designer must get the design into three-dimensional form as quickly as possible.

Making Models and Mock-Ups

The three-dimensional *mock-up*, which costs more than sketches, is an important stage in the development of the design solution, Fig. 11-4. There are three general kinds of mock-ups.

The first is the *paste-up*. This is a very rough mock-up using any material that is suitable. Cardboard is very good. The paste-up gives the designer something to work with and a better idea about the design solution. The paste-up is seldom shown to people who are not designers.

The next kind of mock-up is the *appearance mock-up*. This shows what the product will look like. It too is made out of any suitable materials, usually wood and cardboard. In most cases no parts *function* (work). For example, if it is a sewing machine, none of the knobs or levers will work although they look as if they would. At this stage, it is possible to show design *variations* (differences in small details). If a line of products ranges from inexpensive to deluxe models, the dif-

Fig. 11-3. Rough sketches of good ideas are remade into sketches that people who are not designers can understand. These are called *renderings*.

Fig. 11-4. Three-dimensional mock-ups are often made from renderings.

ferent *modifications* (changes) can be shown as appearance mock-ups.

The appearance mock-up shows, for the first time, a picture of the design solution that is easy to understand and correct. Someone who cannot easily imagine what something looks like from drawings will have no trouble understanding a mock-up of this kind.

The appearance mock-up, however, only looks like the product. Even though it shows the appearance in a fairly *accurate* (correct) way, it cannot be handled and used. The weight is not the true weight of the product. Some of the parts do not show the actual finishes. For example, chrome plating may be shown by silver paper.

When the appearance mock-up has served its purpose, a longer lasting and more exact mock-up is needed. This is called a *hard mock-up*. It is made of metal and wood. Many of the parts will work as they would on the final production model. For example, handles, doors, and lights work, and control knobs turn. But the mechanical parts that make the product work are not included. Thus, a refrigerator mock-up would not have a cooling system. The hard mock-up is used for final explanations, consumer surveys, photography for advertising, market explanations, engineering studies, producibility studies, and further design improvement.

Why Alternate Solutions Are Necessary

In the sketching stage of the design development, the designer comes up with many solutions. This is necessary since the designer is looking for the best ideas. Alternate solutions give him different ways to meet the different *specifications* (requirements). The product designer will try out different materials and production methods, Fig. 11-5. The different design solutions are not shown to top management, engineering, or marketing so that they can make a final choice. Rather, they are shown so that the designer can get information from these groups to help him *formulate* (decide on) possible design solutions. Often only a few possible design solutions can be used since there is not enough room, people, or equipment to make every design into an engineering solution, Fig. 11-6. Too many solutions make this work hard and complicated. It is usually clear fairly early which design solution has the most *potential* (possibilities).

Fig. 11-5. Specialists will help the product designer try out different materials.

Fig. 11-6. Designers must work with the tooling department to work out the best inexpensive method for producing the product. This may require alternate acceptable design solutions.

Once the basic design solution has been decided on, there may still be a need for alternate solutions. This need may come about because of engineering problems. There may not be enough room for one of the *components* (parts). So the product designer makes changes to meet the *dimensional* (size) needs and still keep the design concept. The manufacturing engineering group may ask for similar changes, Fig. 11-7. It may be found that the tooling costs are too high. So the designer must work with the tooling engineers to find some other acceptable design solutions. The same thing could happen if product costs were too high, Fig. 11-8. Then the product designer must work up other solutions to solve the cost problem.

Summary

The product designer has several tools to help him develop design solutions. The two most important are sketches and mock-ups. These tools help him think about different ways to solve the problem. Each tool is important in *communicating* (telling) the designer's solution to others. Sketches are an easy and low-cost method of explaining ideas. Their use is limited, because they are not easily and completely understood by untrained persons. Mock-ups are more complex and expensive but they are a better way to explain the design solution.

Alternate design solutions are needed so that different ideas, materials, and ways of production may be compared. When a line of products is developed, alternate solutions are used to decide which models to make. When engineering and production problems arise, alternate solutions may be used. Tooling and product costs may call for changes in the design. Alternate solutions are worked out to make sure all ways have been studied so that the best possible design can be chosen.

Fig. 11-7. Sometimes the designer must cut down the number of parts to make the manufacture of the product easier or simpler.

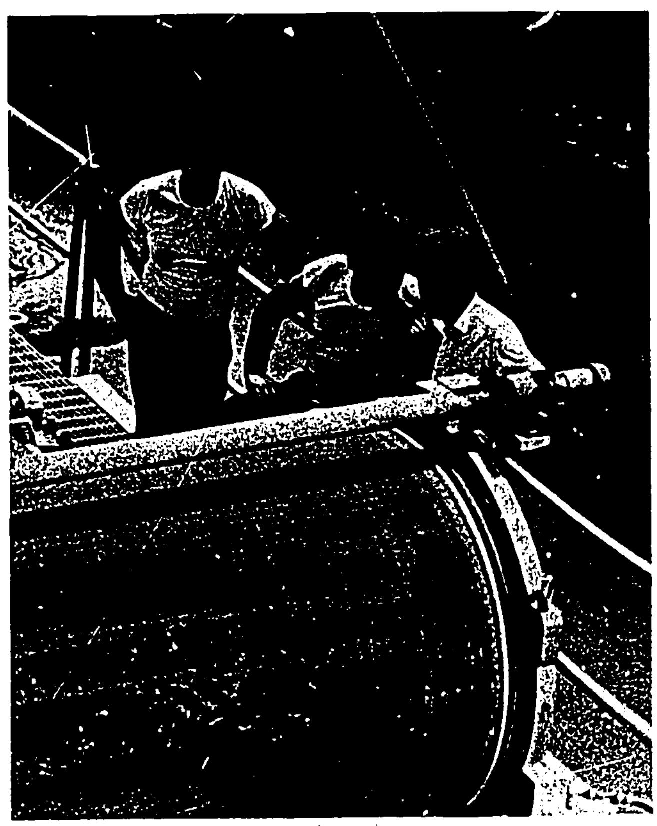


Fig. 11-8. If production costs are too high, the designer may be asked to work up solutions such as a change in finishing requirements.

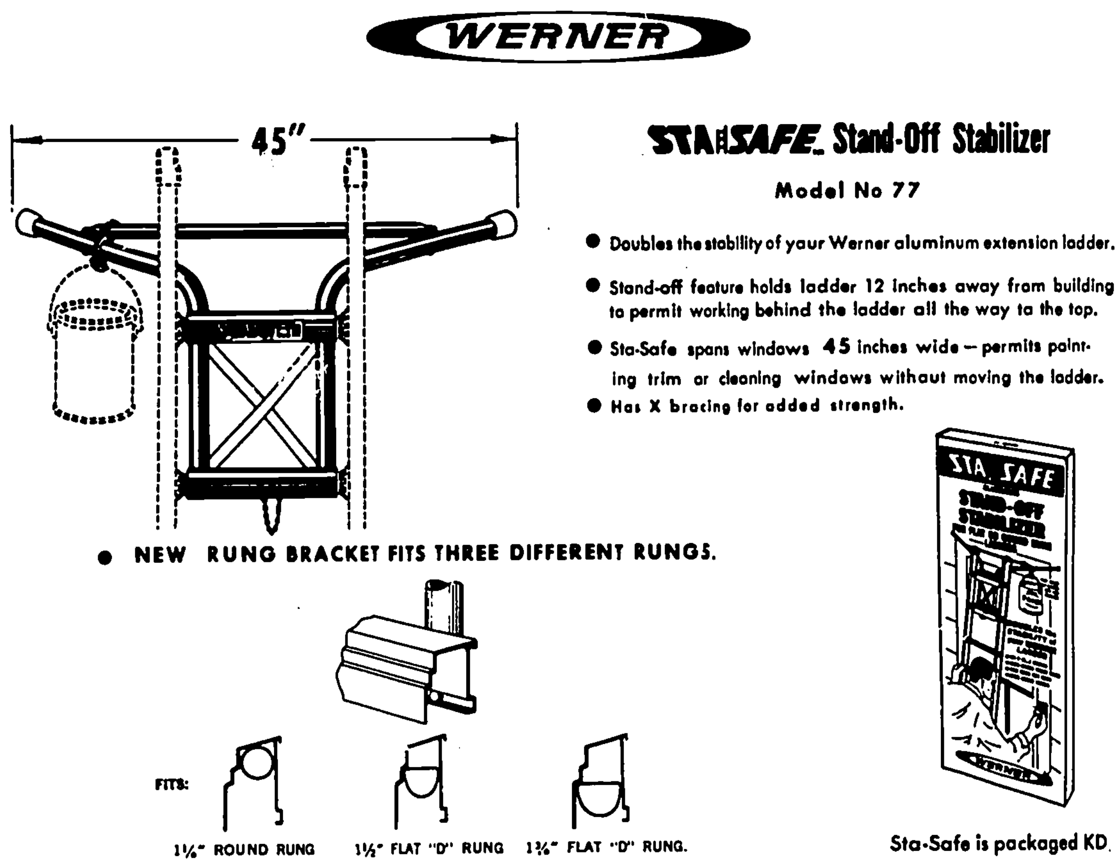


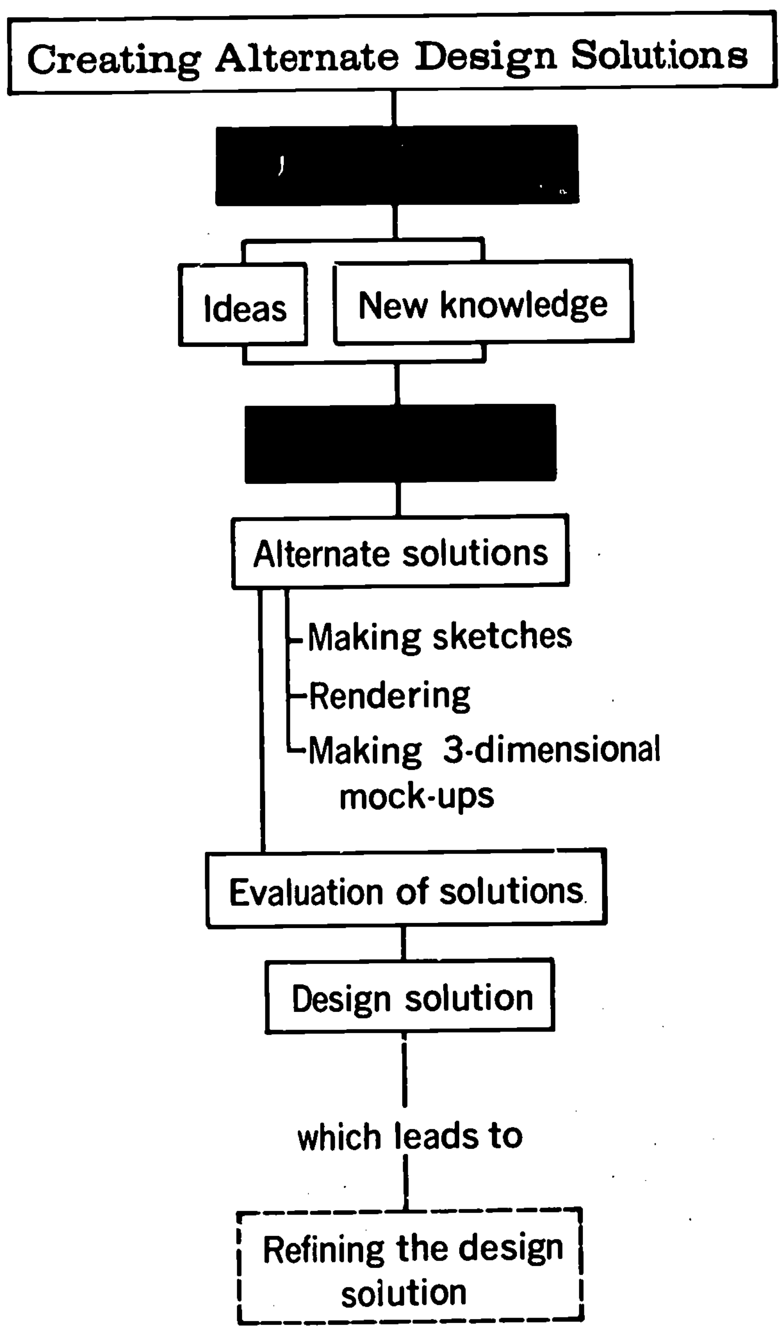
Fig. 11-9. The designer keeps in touch with the product from the first rough sketch until it is packaged.

Terms to Know

design solution	rendering	fabricate	hard mock-up
concept	mock-up	alternate	specifications
design development	paste-up	preliminary	formulate
sketching	appearance mock-up	merits	potential
model making	function	producibility	components
thumbnail	variations	tooling	dimensional
rough	modifications	piece cost estimates	communicating
representation	accurate	presentation	

Think About It!

1. What reasons would top management have for rejecting a designer's *rough sketches?*
2. Do you think *alternate* designs for one product might be useful in arriving at a design solution for another product? Why?


Creating Alternate Design Solutions
Ideas
New knowledge
Alternate solutions
Making sketches
Rendering
Making 3-dimensional mock-ups
Evaluation of solutions
Design solution
which leads to
Refining the design solution

Making Three-Dimensional Models

READING 12

As you have seen from the last reading, three-dimensional models are an important part of the product designing process, Fig. 12-1. *Models are the most important way to explain the design solution.*

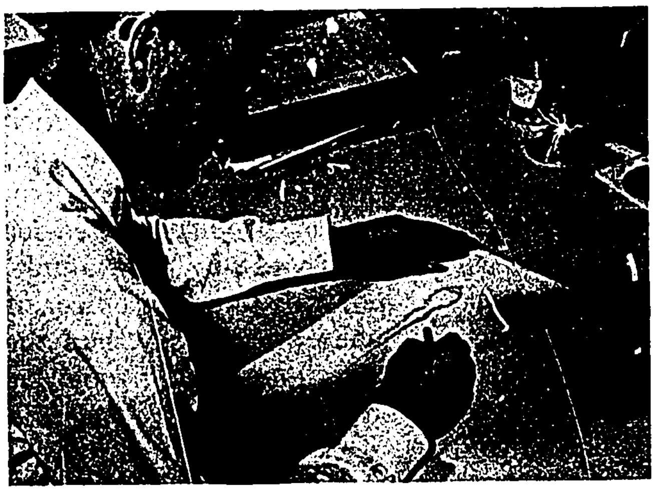


Fig. 12-1. Before a three-dimensional model can be built, a sketch is made.

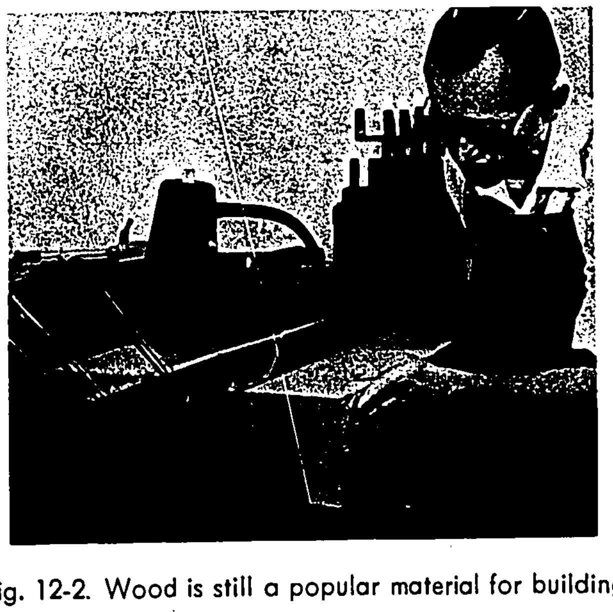


Fig. 12-2. Wood is still a popular material for building models.

A model is anything of a certain form, shape, size, quality, or construction that is made to be imitated (copied). A number of terms refer to a model, but *mock-up* is preferred since "model" often refers to a finished product. For example, "Which model of automobile do you want to buy?" We will look briefly at the different kinds of mock-ups used.

Kinds of Models or Mock-Ups

After the rough sketching, the product designer is usually ready to make a mock-up study. This first rough mock-up is called a *paste-up*. Paper, glue, cardboard, wood, tape, clay, or any material that will easily show the design solution is used, Fig. 12-2. The main purpose of the paste-up is to give the product designer an idea of how the design will fit its surroundings and how people will use it. The paste-up must be made quickly and cheaply.

A *clay model* is used when shape is important to the design, Fig. 12-3. It is easy

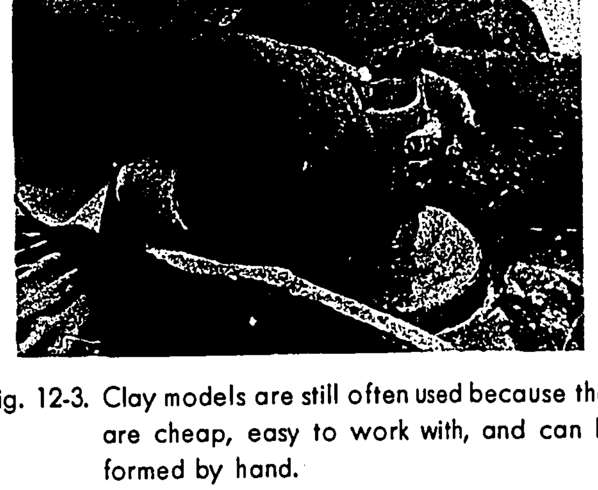


Fig. 12-3. Clay models are still often used because they are cheap, easy to work with, and can be formed by hand.

88

to work with and can easily be changed. Clay models can look like paste-ups; but if special clays are used, they can also be made into very good-looking finished mock-ups.

A *scale model* is another kind of mock-up. It usually (but not always) refers to a mock-up that is smaller than the final product. Examples are scale models of automobiles and airplanes.

An *appearance mock-up* follows the paste-up. It can be made of any material and is usually *full scale* (the same size as the product). It is more completely and carefully done than the paste-up, but it is still a *nonworking mock-up*. The handles, knobs, and doors do not work. Materials and finishes are pictured as correctly as possible.

A *hard mock-up* is usually the final mock-up. It is well-made, and important parts such as drawers, knobs, lights, doors, and wheels will work. Materials and finishes should be the same ones that will be used in actual production, Fig. 12-4. It does not include the power units or the basic working parts, such as the cooling system in a refrigerator or the engine in an automobile.

Fig. 12-4. A mock-up can be made of the materials that will actually end up in the product.

Working Models or Prototypes

Models in which all parts work and which also include all details of appearance are called *working models* or *prototypes*. Prototypes of some kinds of products are easier to make than others, Fig. 12-5. For example, the prototype for a pair of pliers or a piece of furniture can be made more easily than the prototype for an airplane or a locomotive engine. Reading 18 covers the prototype in greater detail.

Fig. 12-5. From a sketch, a handmade model can be formed. In this case, a usable product was made using similar steps.

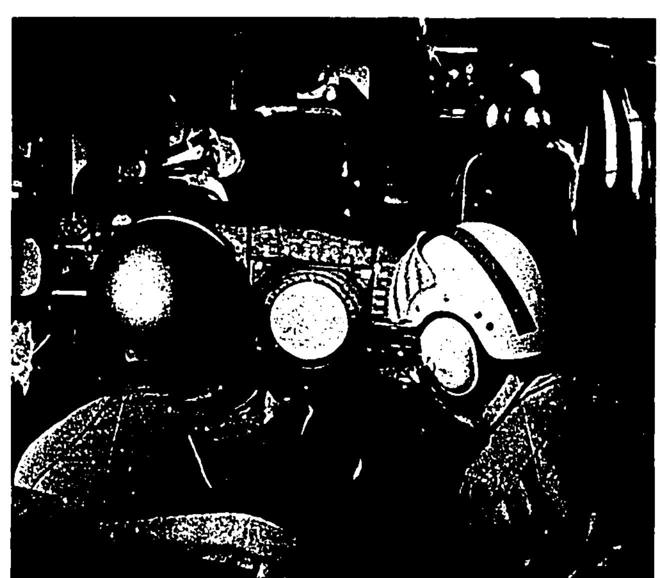


Fig. 12-6. This mock-up of a trainer plane is useful for human engineering studies as well as for training pilots to fly.

Where Mock-Ups Are Used

Mock-ups are often used in *product presentations* (explanations). They are also used in other design studies, such as a *human factors engineering study,* Fig. 12-6. This can apply to the *interior* (inside) of an automobile or the cabin of an Apollo Moon Vehicle. In both cases the location of the controls and the kind of seating and space that the human body needs must be studied, Fig. 12-7. The best way to study these things is to make a mock-up of the interiors and work with them.

Hard mock-ups that are well made are needed for consumer surveys. They must look like production models since a poor imitation might cause the consumer to react unfavorably to the design solution, Fig. 12-8. Models are also used to give information to the *toolmaker*. Many parts with unusual shapes are hard to show correctly in a drawing. To solve this problem, an accurate wooden model is made and then given to the toolmaker to copy into a steel mold (*die*).

Many times, sales and advertising literature for a product must be prepared before the product is manufactured. If pictures of the product are needed, the hard mock-up is photographed. Sometimes, hard mock-ups are *presented* (shown) to future customers. Then, orders based on the mock-up are taken. This was true in the case of the SST airplane. The actual airplane may be built years after the first orders are taken.

How Mock-Ups Are Made

Mock-ups are made either by the product designer or by persons trained to make models. The mock-ups built by the product designer are usually paste-ups. The designer must be able to cut and shape paper, cardboard, clay, wood, plastic, or any other suitable material. He must be able to fasten parts together with glue, tape, and simple mechanical fasteners like staples. The designer must be able to work with his hands. As he builds the mock-ups, he is also designing.

Where people trained to make models are employed, the designer must give them *dimensional drawings* (drawings that show sizes and shapes) of the mock-up. He must also help them work out ways to get the

Fig. 12-7. This is a one-fifth scale model of a man in a seated position at the controls of a spaceship.

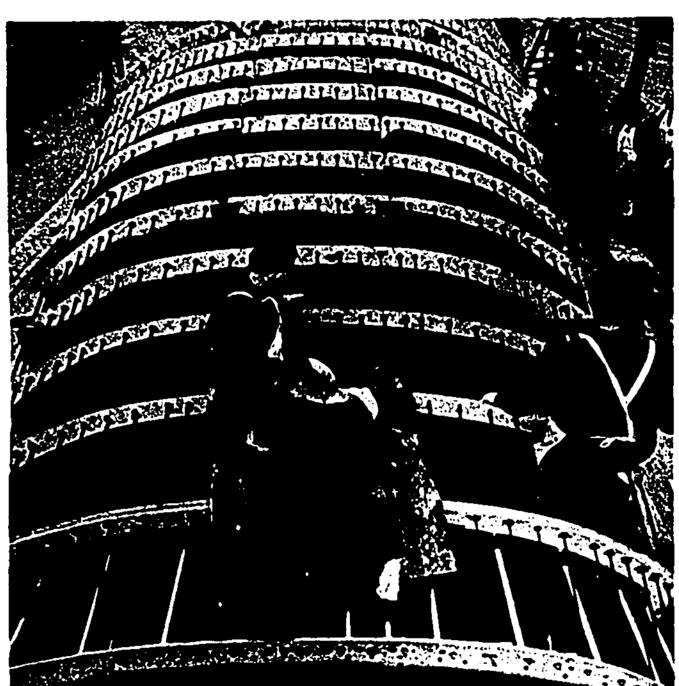


Fig. 12-8. Here the permanent model for the fuselage section of the Boeing 747 is taking shape.

desired effects, Fig. 12-9. The *model maker* is a specialist who must have many skills. He must be a machinist, a cabinet-maker, a pattern maker, and a painter. He must understand what the designer is trying to make through the mock-up.

Summary

Mock-ups are the most important way to explain the design solution. There are different kinds of mock-ups, each with its own name. The paste-up is used in the early stages of the design. Next, the appearance mock-up is made. This is an accurate, visual representation of the product. Finally, the hard mock-up is made. This is well made and accurate in all details, and all the parts work. These mock-ups are used for explanations, consumer surveys, photography, and any other situation that calls for a representation of the product.

When the product designer is still developing the design, he may build his own mock-up, usually a paste-up. When the design problem has been solved, a person trained to make models makes the appearance or hard mock-ups.

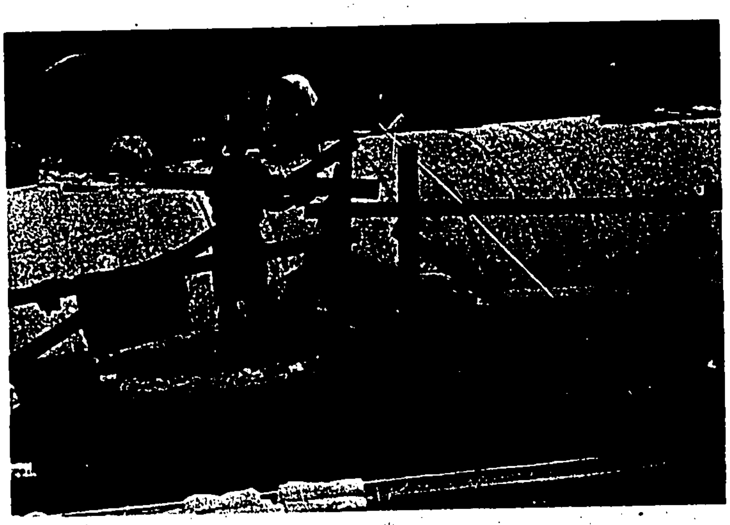


Fig. 12-9. Plaster is used to finish the surface on the fuselage section of this model of the Boeing 747. This is the largest model ever made of a commercial airplane.

Making Three-Dimensional Models

- [redacted]
  - Analyzing sketches
  - Analyzing renderings
  - Analyzing 3-dimensional mock-ups
- [redacted]
- [redacted]
  - Interpreting sketches
  - Fabricating
  - Finishing the model

Terms to Know

model	working models
imitated	prototypes
mock-up	product presentations
paste-up	human factors engineering study
clay model	interior
scale model	toolmaker
appearance mock-up	presented
full scale	dimensional drawings
nonworking mock-up	model maker
hard mock-up	

Think About It!

1. Why would it be important *for the designer* to have a *mock-up* of the interior of the Apollo Lunar Excursion Model (LEM)?
2. What benefits does the product designer get from showing *hard mock-ups* (or pictures of them) to future customers? What disadvantages are there?

Refining the Design Solution

READING 13

The design for a product is always studied and *refined* (improved). This is part of the industrial designer's job. Usually it is possible to find out if the product will *be and do* what the design solution planned. A sample of a product can be made and tested. If changes are needed, the designer will make the changes in the design solution. For example, a machine can be built, run, and studied. Any needed *adjustments* (changes) can be made by testing its performance.

It is much harder to measure the effect of a product's *appearance* when it is still in the design solution stage. Management must know as much as possible about *consumer acceptance* (whether people will buy), Fig. 13-1. If a product's appearance can be improved before full scale production starts, the designer must know this. Others in management may also need consumer information. To help them, different kinds of *consumer surveys* are made.

Fig. 13-1. The consumer is the final judge of product design.

Kinds of Consumer Surveys

Consumer surveys are expensive, but they get several kinds of useful information. Some *data* (facts) help the designer improve a product. Other facts convince management that the product will sell. For this reason, great amounts of time and money are spent to develop the product. A consumer survey can also show what the selling price should be and the kind of people who will buy the product. It can help the *marketing* group (those planning the sales) to decide how to *market* (sell) and advertise the product.

A survey can be made at any point in product development, depending upon what kind of information is needed. A new product idea, never before given to the public, is surveyed as soon as possible. If a survey shows consumer acceptance of the idea, time and money may be spent to develop it further. New *features* (parts) of products already on the market are surveyed to see if consumers will accept the changes. Management asks for this kind of survey before approving the expenses of *retooling* (changing the production machines so new parts of the product can be made).

Consumer surveys are made to give the kind of information needed. They must be carefully planned so the information will be useful.

Consumer surveys are run by specialists in *market research* who are trained in the different ways of *conducting* (getting useful information), *tabulating* (summing up the information), and *evaluating* surveys (deciding how the information affects the sale of the product). They work with the design staff in deciding what information to get

and they suggest the kind of survey that should be used. Then, marketing decides where and when it will be done.

Prototypes (developmental or working models), made by the product design group, are shown to the people who are being surveyed. The people look at the models and even handle them. Then they make a choice, Fig. 13-2. It is very important that the *brand names* of products are hidden from the people. Brand names can influence choice. If the brand names are not hidden, the survey results may not show whether the people accepted the appearance and features of a prototype. People are often asked in a survey to compare one design solution with another, or perhaps with a model made by another company.

It is also important to decide who will be surveyed. This is called *screening*. If it is known what kind of people might buy a product, these people will be chosen to take part in a survey. For example, if a product is bought by married women under 35 years, there is no sense in getting the opinion of men, single women, or women over 35 years of age.

Surveys in different geographic locations give different results, Fig. 13-3. People who live on the West Coast may not react like people who live on the East Coast. People who live in cities may react differently from people who live in suburbs, so a survey is usually done in three or four locations to get a good *cross section of opinion*. There are market research companies in many places

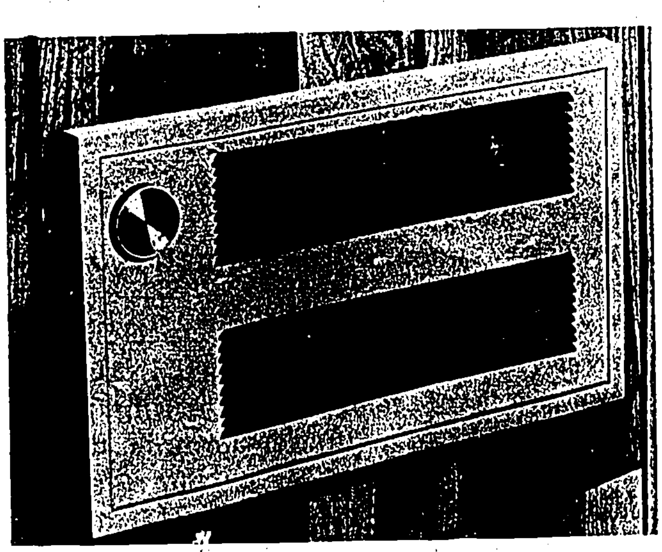


Fig. 13-2. Prototypes are used for comparing designs.

Fig. 13-3. A cross section of the intended market is needed. The locations where a survey will be made are marked on the map.

FREE 3-YEAR FACTORY SERVICE CONTRACT APPLICATION

PURCHASER: ________

ADDRESS: ________

CITY: ________ ZIP CODE ________

MODEL: ________ DATE OF PURCHASE: ________

SERIAL: ________

DEALER FROM WHOM PURCHASED: ________

CITY: ________

I have filled in all the above information, I understand that the service contract covers all parts and materials that might be used to service my equipment for three years from the date of purchase. I also understand that it does not cover tubes, fuses, or transportation to and from the factory. I understand that the service is to be done only by the factory in Binghamton, New York or by a McIntosh Authorized Service Agency. This contract, of course, does not cover equipment that has been misused, received unauthorized service, or maladjusted.

This equipment was purchased on the above date.

Signed ________

THIS APPLICATION MUST BE POSTMARKED WITHIN 30 DAYS OF PURCHASE TO BE VALID!

Would you please take a moment to help others enjoy the best in high fidelity equipment by answering these questions?

1. I first learned of McIntosh through: Advertisement in ________, Recommendation of friend ☐; Demonstration by dealer ☐; at an audio show ☐.
2. What feature of the McIntosh attracted you most? ________
3. Did your McIntosh equipment replace any previously owned high fidelity equipment? If so, describe briefly: ________

Thank you. Frank H. McIntosh

McIntosh LABORATORY INC. 2 Chambers St., Binghamton, N. Y. 13903

Fig. 13-4. Warranty cards furnish marketing information.

throughout the country. A market research company can reach any kind of people needed for a survey. These people are called *respondents.*

Conducting Consumer Surveys

When you buy a new product, you are often asked to send a *warranty* card back to the manufacturer, Fig. 13-4. On the card are some questions asking why you bought the product and where you bought it. This is one kind of consumer survey, and you are a respondent. There are many other kinds.

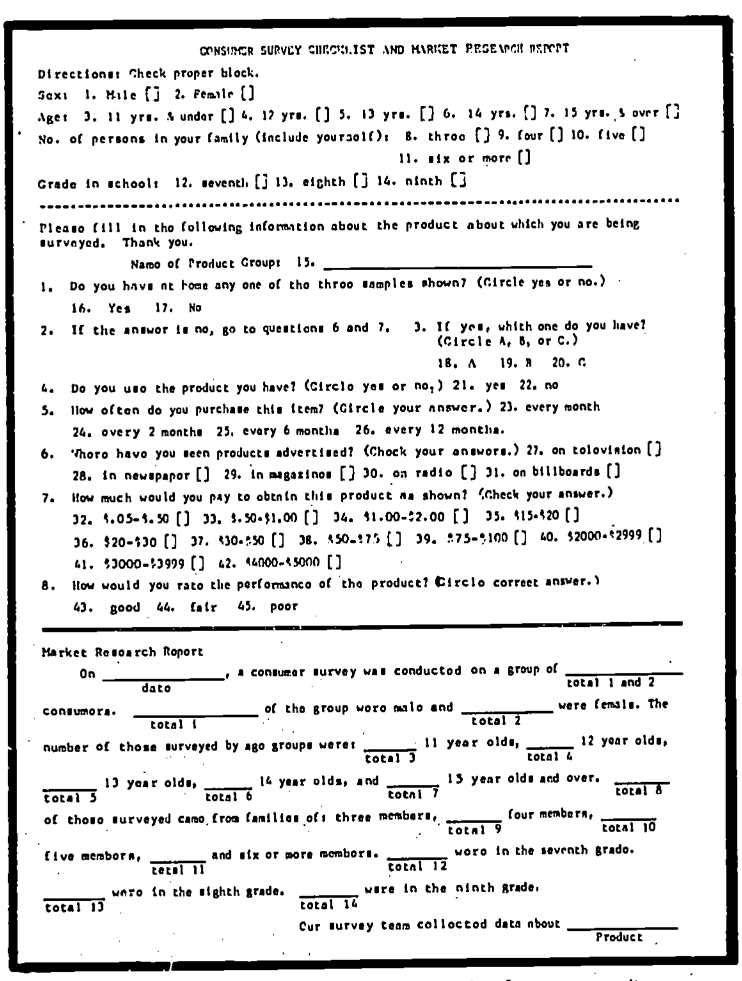
Two kinds of surveys are often used to measure consumer acceptance. One is the *interview.* The other is the *panel discussion.* Both kinds are often used in the same survey.

The interview can get a large number of opinions in a fairly short time, Fig. 13-5. It is helpful when the choices given to respondents are simple. Let us look at a *typical* (usual) *interview* survey. We want to know if people will like the *exterior* (outside) and *interior* (inside) of a new refrigerator design. The design group makes two prototypes of the proposed design solution. They are similar in size but each is different in appearance and features. A similar model of a brand made by another company is also used. This gives the respondent three choices.

Fig. 13-5. Interviews may establish a need for a new product.

If the survey will be conducted in Los Angeles, Indianapolis, and New York, market research groups in these three cities are contacted and dates are set up. *Questionnaires* (sets of questions the respondents are to answer) are worked out. Each research group is asked to do the survey in exactly the same way.

Since it is necessary to talk to a large number of people, a busy place must be found. A shopping center is a good location. The models are set up in a suitable place. They are labeled with the letters *R, S,* and *T;* and no brand names show. Several research workers conduct the interviews. Using the questionnaires, they stop people who are passing by and ask if they are willing to take part in a consumer survey. If the answer is "yes," the interviewer asks the questions on the questionnaire, Fig. 13-6.



CONSUMER SURVEY CHECKLIST AND MARKET RESEARCH REPORT

Directions: Check proper block.

Sex: 1. Male [] 2. Female []

Age: 3. 11 yrs. & under [] 4. 12 yrs. [] 5. 13 yrs. [] 6. 14 yrs. [] 7. 15 yrs. & over []

No. of persons in your family (include yourself): 8. three [] 9. four [] 10. five [] 11. six or more []

Grade in school: 12. seventh [] 13. eighth [] 14. ninth []

Please fill in the following information about the product about which you are being surveyed. Thank you.

Name of Product Group: 15. ____________

1. Do you have at home any one of the three samples shown? (Circle yes or no.) 16. Yes 17. No
2. If the answer is no, go to questions 6 and 7.
3. If yes, which one do you have? (Circle A, B, or C.) 18. A 19. B 20. C
4. Do you use the product you have? (Circle yes or no.) 21. yes 22. no
5. How often do you purchase this item? (Circle your answer.) 23. every month 24. every 2 months 25. every 6 months 26. every 12 months.
6. Where have you seen products advertised? (Check your answers.) 27. on television [] 28. in newspaper [] 29. in magazines [] 30. on radio [] 31. on billboards []
7. How much would you pay to obtain this product as shown? (Check your answer.) 32. \$.05-\$.50 [] 33. \$.50-\$1.00 [] 34. \$1.00-\$2.00 [] 35. \$15-\$20 [] 36. \$20-\$30 [] 37. \$30-\$50 [] 38. \$50-\$75 [] 39. \$75-\$100 [] 40. \$2000-\$2999 [] 41. \$3000-\$3999 [] 42. \$4000-\$5000 []
8. How would you rate the performance of the product? Circle correct answer.) 43. good 44. fair 45. poor

Market Research Report

On ______ (date), a consumer survey was conducted on a group of ______ (total 1 and 2) consumers. ______ (total 1) of the group were male and ______ (total 2) were female. The number of those surveyed by age groups were: ______ (total 3) 11 year olds, ______ (total 4) 12 year olds, ______ (total 5) 13 year olds, ______ (total 6) 14 year olds, and ______ (total 7) 15 year olds and over. ______ (total 8) of those surveyed came from families of: three members, ______ (total 9) four members, ______ (total 10) five members, ______ (total 11) and six or more members. ______ (total 12) were in the seventh grade. ______ (total 13) were in the eighth grade. ______ (total 14) were in the ninth grade.

Our survey team collected data about ______ (Product)

Fig. 13-6. Questionnaires are used for recording information.

The first few questions are the *screening* questions. They show whether the respondent fits the needs of the survey. In this case the respondent can be either male or female, but he must live in a house rather than an apartment. His (or her) present refrigerator should be at least five years old. This is usually the kind of person who would probably buy a new refrigerator.

If the answers to the screening questions are satisfactory, the respondent is shown the models: *R*, *S*, and *T*. His opinions are recorded. Typical questions would be: "Which refrigerator do you like best?", "Which second best?", and "Which least?". Completing the questions takes from 10 to 15 minutes. Nearly 100 people can be interviewed in eight hours, Fig. 13-7.

The *panel discussion* kind of survey differs from the interview. It not only finds out how consumers react, but it looks for the *reasons* for the reaction, Fig. 13-8. It is made up of a group of people called a *panel*. They are asked to talk about the design proposals. The usual panel has 10 people.

There is a special way to select the members of a panel. Market research people, for example, go to women's clubs and social organizations. They offer to pay a small sum of money to the club treasury for each club member who takes part in a panel.

The panel respondents are brought together and are shown the design. Then a market research worker leads the group into a discussion. It is his job to ask the people for their opinions. He must be careful, however, not to influence them in any way. By talking to the people he gets information on how the product will be used, how it should be sold, and even how much money people will pay for it. If there are certain features that the people like, the research worker tries to find those features. There may be some features that the people do *not* like, so he will try to find out why they do not like them. Both of these findings are important to the product designer. Now he can change his designs so that people will accept them. Six to ten groups or panels will usually give enough information for a survey. Everything that is said is recorded. There are questionnaires that must be filled out by panel members.

You can see that surveys need careful planning. They are also expensive. If a great many opinions are needed, the interview method is very good. If more complete information is needed, the panel discussion is better.

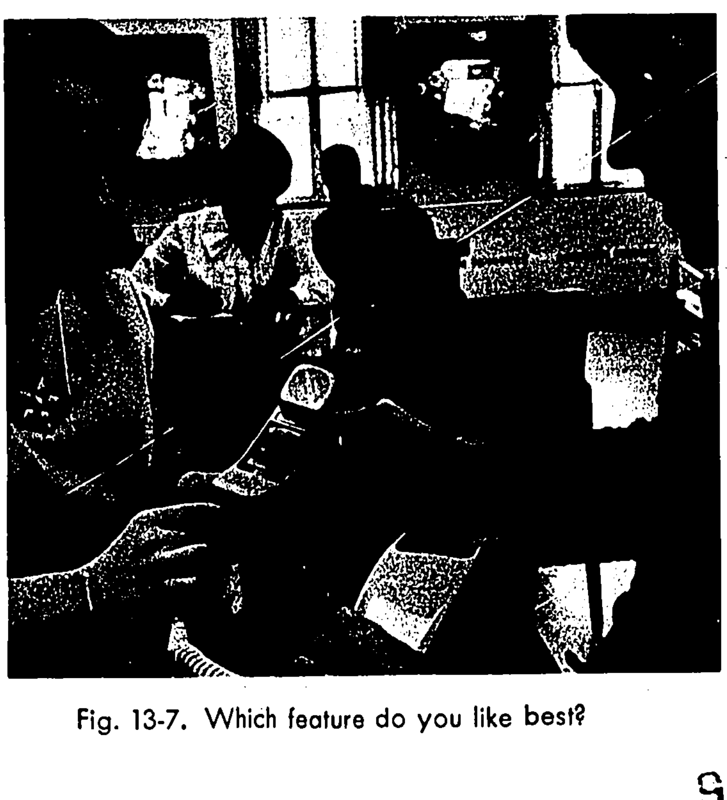


Fig. 13-7. Which feature do you like best?

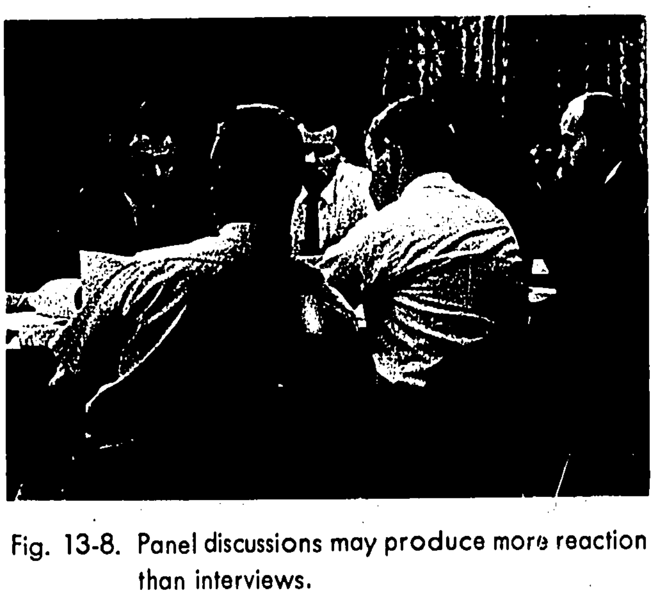


Fig. 13-8. Panel discussions may produce more reaction than interviews.

Tabulating and Evaluating Survey Results

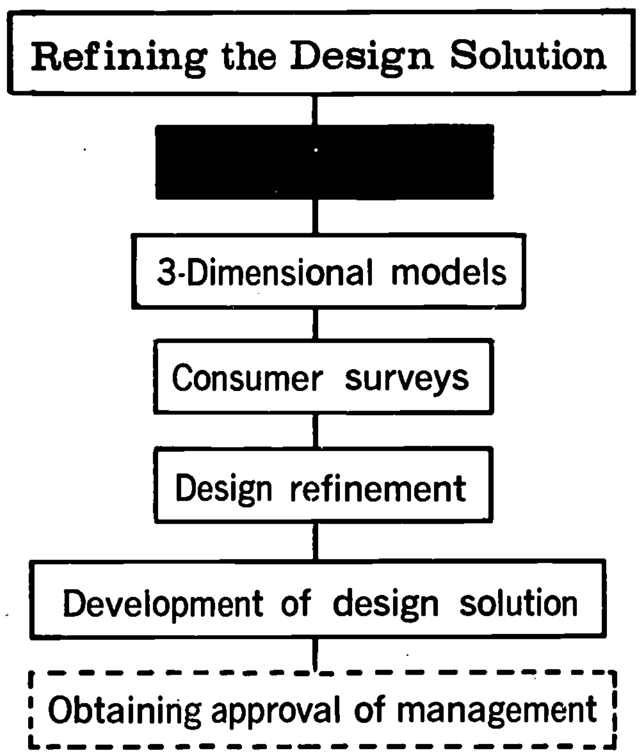
The purpose of a survey is to get useful information for the designer and for management. When the survey is finished, the information is *tabulated.* That is, it is written up in an orderly way so that the results are easy to understand. This is the job of the market research groups. They also study survey results and give their opinions on what the results show.

The product designer can now study the survey results and judge his own work. He must decide if his design solution is good or if it should be changed. When he presents the product design solution for final management approval, he uses the survey information to *support* (explain) his judgment. For example, management may ask the product designer why he used a long handle on a refrigerator door. His answer might be that the consumer survey showed that consumers wanted a long handle.

The designer depends on the survey as an important tool in developing a product design. To be useful, surveys must be well done and correctly evaluated. Some products have been surveyed a great deal, but have failed when they were placed on the market. The Edsel automobile is an example. Surveys showed that people would buy the car. When it came on the market, very few people bought it. This is why a survey may be used to help make a final judgment, but it should not be thought of as being the final judgment.

Summary

A product design is always studied and improved throughout the development process. *Consumer surveys* are one way of getting *data* (information) about how the customer feels about a product. The *interview* can give many opinions in a fairly short time. The *panel discussion* not only gives opinions but also the reasons for people's opinions. Designers use surveys to support their design solutions. Surveys give management added confidence before they give their final approval. Surveys must be done well by market research specialists.



Terms to Know

refined
adjustments
appearance
consumer acceptance
consumer surveys
data
marketing
market (sell)
features
retooling
market research
conducting
tabulating
evaluating
prototypes
brand names
screening
cross section of opinion
respondents
warranty
interview
panel discussion
typical
exterior
interior
questionnaires
reasons
panel
tabulated
support
rejected
marketed

Think About It!

1. If you had designed a new motorcycle, what groups of people would you want *market research* teams to *interview?* What questions would you want them to ask these people?

2. What products have you used which you would have *rejected* if interviewers had asked your opinion before they were *marketed?* Why would you have rejected them?

Obtaining Approval of Management

READING 14

This reading describes the steps leading to a major decision. The decision will put the design solution into product engineering and production planning. This decision is called *final management approval.*

Approval Procedure

To get ready for this approval, usually a number of meetings are held. Personnel from the marketing, finance, engineering, and production departments meet with the product designers. Information from these meetings is collected, put into final form, and *presented* (given) to management for approval. In this final presentation, the *design solution* plays a major part.

Every design in its final form has been developed from a *concept* (idea) and has gone through several stages to a design solution. In small companies only a few people take part, and the *development process* can be informal. In large companies, where many people take part, development is a more formal process, Fig. 14-1. This is necessary to keep everyone informed and to prevent confusion.

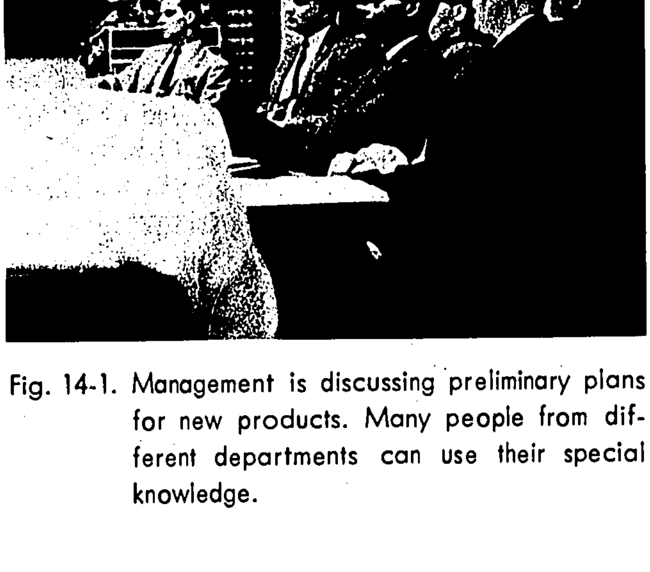


Fig. 14-1. Management is discussing preliminary plans for new products. Many people from different departments can use their special knowledge.

We will look at the steps leading to management approval of a design solution. We will look at each of these steps as it affects the designers. Our example will be a large company with its own *internal* design group.

Before final management approval, there are points along the way that need approval. These approvals are gotten through meetings. Both *preliminary* (beginning) *meetings* and the final meetings are called *product planning meetings*. Five meetings will be described. Sometimes fewer meetings can be held.

First Product Planning Meeting

Product planning may be *initiated* (started) because of a new product made by another company, an invention, or a new product design idea. The product design, manufacturing engineering, production, and marketing departments send people to this

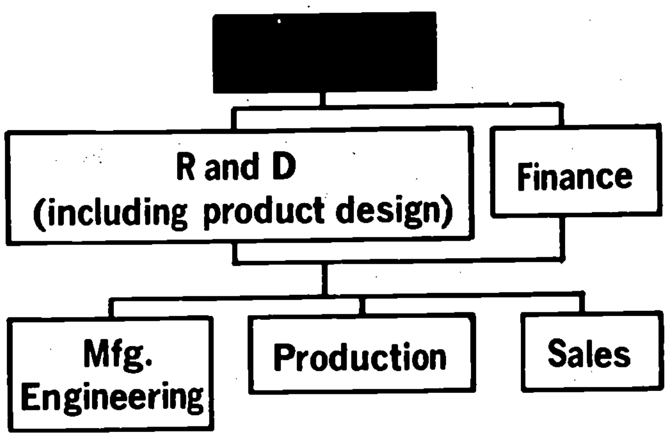


Fig. 14-2. Everyone from the president to the shop foreman may take part in approving the design for a new product.

meeting, Fig. 14-2. It is a planning meeting.

This meeting must be held from six months to a year before the final meeting. When it is held depends on how much time is needed to develop the product.

The designers leave the meeting with a rough outline of the *design requirements*. In a few weeks they will get a great deal of information about the design solution. They will study products made by other companies. They will study new techniques that might be useful in planning the product. The designers will start thinking about the different jobs the product must do. They will make sketches and rough cardboard mock-ups to help them in the studies and to show *alternate solutions*. Much of this activity is done to get ready for the next meeting.

Second Product Planning Meeting

This meeting is called a *feasibility meeting* (deciding whether the product can be produced). Since the first meeting, facts have been gathered in rough form about cost, *market potential* (possible sales), product features, and other problems. The design group now presents sketches and rough mock-ups to show some features of the product concept.

This is the meeting that decides whether or not the project is *practical* (useful). The division manager is there. One of the purposes of this meeting is to present the product plans to him for his approval. He manages the production, manufacturing engineering, and marketing departments. The *director* (chief) of each department is also there.

The *product development schedule* (time periods that each department will work on its part of the product) is made final at this meeting. Dates for the next product planning meetings are also set.

The design group leaves this meeting with a good idea of tooling and product costs and of engineering problems. The appearance of the product now becomes a major problem. The designers will continue to work with sketches and mock-ups, refining (improving) their design solutions as problems become clearer.

During this period the design group will meet often with industrial and manufacturing engineers. They are getting ready for the next meeting for which they will need good design mock-ups.

Third Product Planning Meeting

Product, tooling, and *facility* (manufacturing plant) costs must be ready for this meeting. All major engineering problems must be solved before the meeting. The designers make a full *presentation* (explanation) of their final design solution. The mock-ups look as much like the product as possible. Parts that will be handled or operated by the user will work, Fig. 14-3.

The division manager along with his marketing, production, and manufacturing engineering people are at this meeting. The meeting is held at least one month ahead of the final approval meeting to allow enough time to *modify* (change) designs and get more information; for example, to run a consumer survey. The meeting must end with general agreement by everyone. Otherwise,

the project will be delayed until all can agree.

If earlier meetings have been well run, no serious problems should come up at this meeting. If the design solution is good and the product and tooling costs are satisfactory, the date for the final meeting can be set. The *design group* leaves this meeting with the job of making minor *refinements* (improvements) and additions to the design solution.

Fourth Product Planning Meeting

This meeting is a rehearsal for the final one. It is held about one week before the final management approval meeting. Every detail must be covered. The same people who were at the third meeting are at this meeting. The final meeting date is then set, and the last few days are spent making last minute changes.

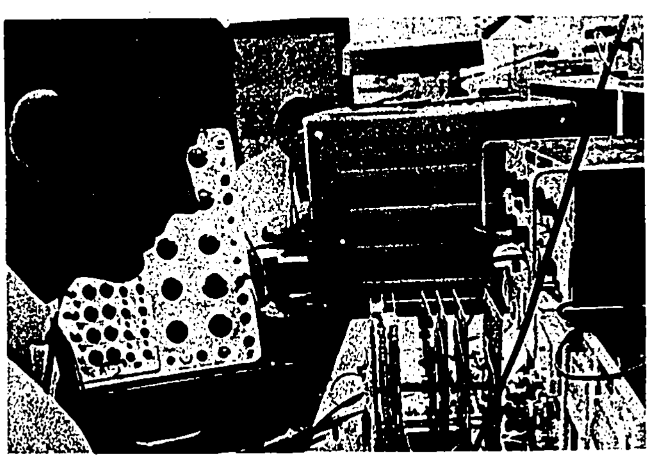


Fig. 14-3. An electric circuit is tested to see if it will work. Many ideas are tested to see if they are useful before being put into a product.

Last Product Planning Meeting

At this meeting management gives its final approval. The meeting must be scheduled so that there will be enough development and tooling time to meet the scheduled production date. If the product is a kitchen appliance, for example, the meeting would take place from nine to twelve months before production, Fig. 14-4.

The decision to make a product is not based on appearance alone. But the appearance of a product cannot be separated from the whole product plan, so the presentation must be complete in every detail.

Usually, *one person* gives the final management approval. In a small company, the final decision might be made by the owner. In a large corporation, it is made by a group vice-president. A group vice-president manages a number of *divisions*. He may have working under him a group that makes television sets, a group that makes refrigerators, and seven or eight other groups. He, in turn, works under the president of the corporation for the proper management of these groups (divisions). The important point is

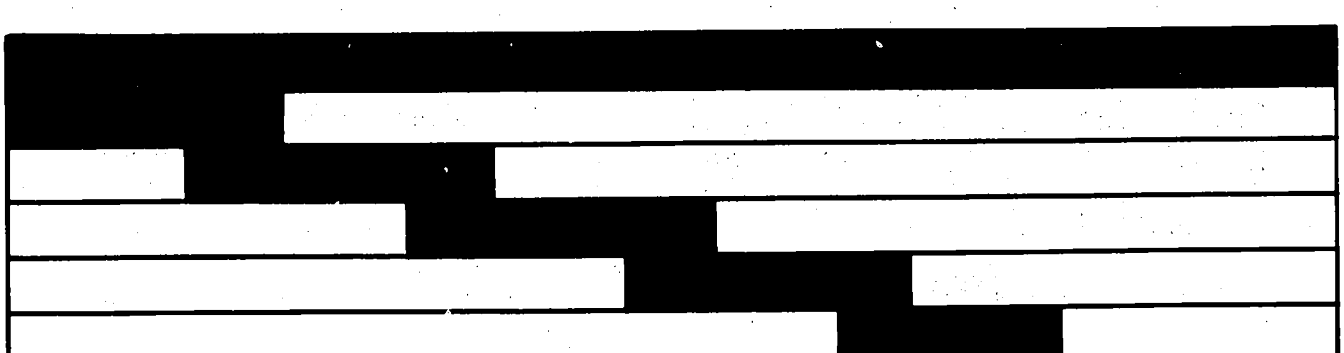


Fig. 14-4. Designing and planning must be scheduled. Each department needs a certain amount of time to do its share. Each department must wait for another to do its work before it can begin.

that the final approval will be given by *one person*, the president or vice-president. How much he takes the advice and suggestions of his staff depends as much on his personality as on their ability. A product plan will not get to this point unless the division manager feels reasonably sure of getting approval.

The only people at this meeting are the vice-president; his administrative and financial assistants; the division manager with his marketing, manufacturing engineering, and production chiefs; and the product design director with one or two of his designers.

The meeting is divided into four stages. The *product design director* begins the meeting by explaining why the new product is needed. He shows and discusses products made by other companies. He uses charts, photographs, and actual products. This gives a quick but *comprehensive* (broad) understanding of the market for this product.

Fig. 14-5. The top manager gives his final approval to a new product design. The product is now ready for production scheduling.

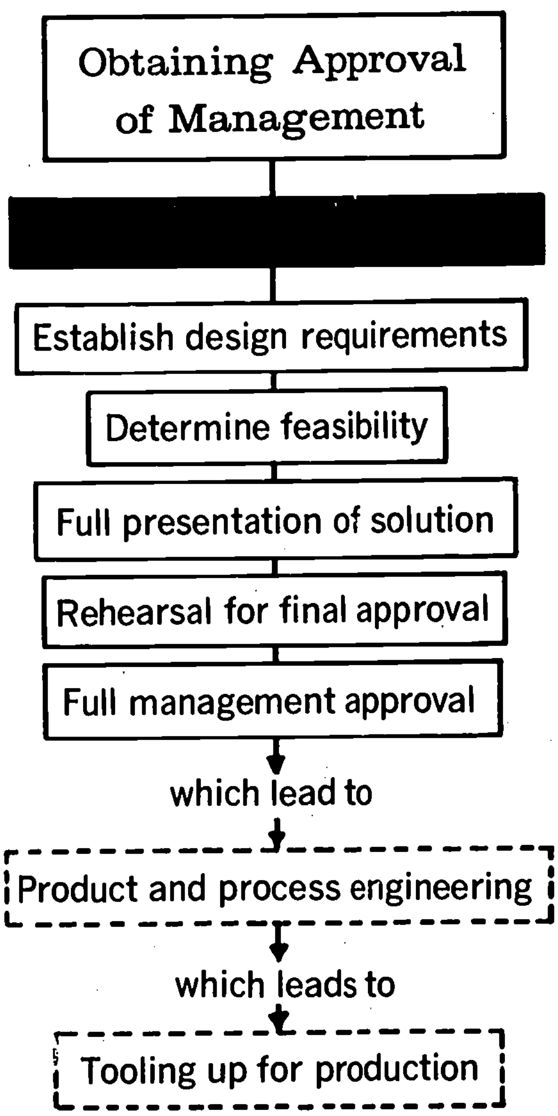
Next, the meeting is turned over to the *design staff*. Designers present their mock-ups of the design solution. No alternate solution is presented. This is not always the case, but it is more useful to decide on one solution before the final meeting. Designers can best explain the appearance of the design solution. They explain the design solution fully, giving reasons for each part of the design. For example: "The control panel is angled to provide better readability," or "Our color surveys show that this color will be very popular next year." Then they give any data from consumer approval surveys that back up these statements.

After the design solution has been fully demonstrated and explained, the meeting is turned over to the *division manager*. He presents the tooling and plant needs, as well as the expected profit.

Finally, a *marketing expert* presents the marketing plans. Then, if the product plan has been well thought out and presented, it will get management approval. The official go-ahead is given, and *commitments* (promises) of time and money are made, Fig. 14-5.

Summary

As we can see, *obtaining* (getting) management approval starts long before the final meeting. Several formal product planning meetings and many informal meetings are needed for final approval. Each meeting gives people more information and improves the design solution. No one department working alone designs the product. Product designers combine information and advice from many departments into a design solution. The final meeting is carefully planned. The presentation is complete in every detail. Tooling and product costs, facility needs, marketing, possible profit, and design are all thoroughly explained. All the information needed to make the decision is presented. This is how final management approval is obtained.



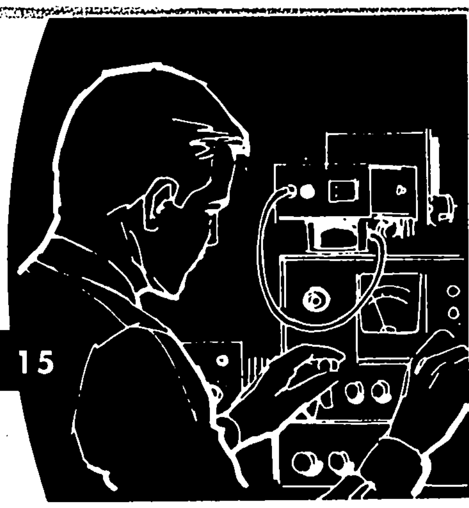
Terms to Know

final management approval
presented
design solution
concept
development process
internal
preliminary meetings
product planning meetings
initiated
design requirements
alternate solutions
feasibility meeting
market potential
practical
product development
schedule
director
refining
facility
presentation
modify
design group
refinements
divisions
product design director
comprehensive
design staff
division manager
marketing expert
commitments
obtaining
final decision

Think About It!

1. This reading describes the many steps needed to get the approval of top management in large corporations. How would these decisions be reached in a small company?
2. If you were in charge of making the *final decision* on the product design for a new automobile, what would *you* want to hear from your product design staff in the presentation?

READING 15



Engineering the Product

In earlier readings you have studied the work of the product design group. This group decides on the *function* (working) and appearance of a product. In later readings you will study the work of the production planning group. Before production can be planned, however, there is often much detailed work to be done. This reading describes the work of the *product engineer*. He must change the product design, which sometimes shows only the *exterior* (outside) appearance, into *detail drawings* and *specifications*, Fig. 15-1.

Product designing and product engineering are not entirely separate jobs. The designer of an air conditioner must think about the sizes of the motors that will be needed. A dress designer must know the strength and draping qualities of different fabrics. When a product engineer chooses an automobile engine, its size and shape must agree with the exterior body size and shape the designer has planned. If the engine cannot be changed, the body design must be *modified* (changed).

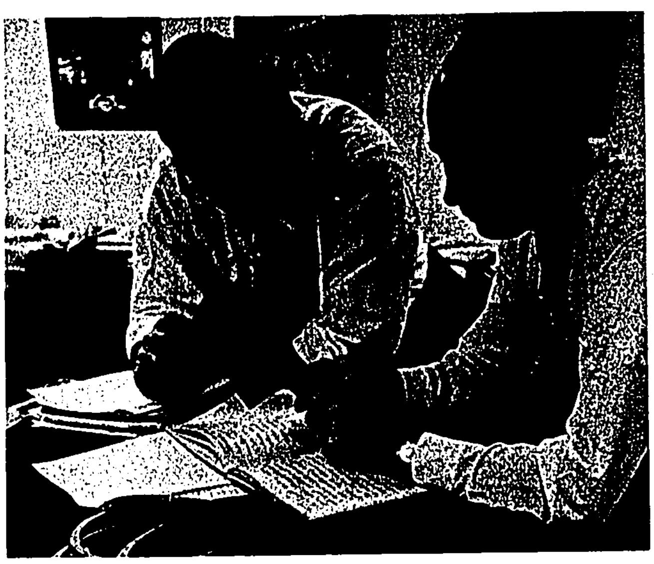


Fig. 15-1. The product engineer must complete the design details.

Product Engineering

There are four main kinds of activities in product engineering:

1. Designing power *elements* (parts), mechanical *assemblies*, and other *interior* (inside) parts;
2. Making *working drawings;*
3. Building the production *prototype;* and
4. *Technical writing and illustrating.*

To understand these activities better, suppose that the function and appearance of a bicycle have been decided in a general way. Perhaps surveys have shown that consumers want a certain kind of speed control mechanism. Perhaps they want the bicycle to work at certain speeds. A product engineer must design the gears to meet these consumer needs, Fig. 15-2.

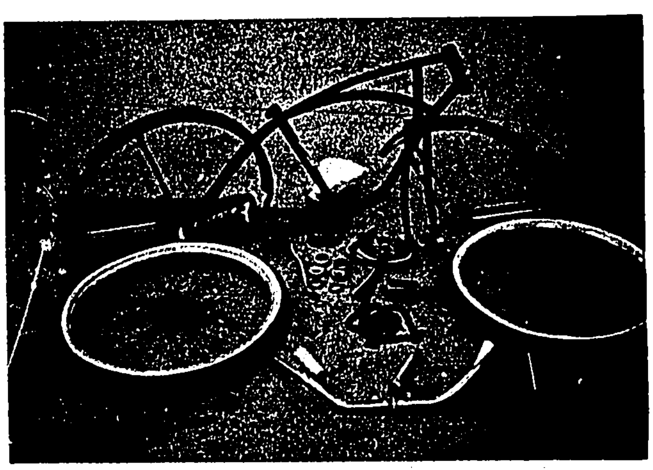


Fig. 15-2. Each part of a product must be designed for strength, life, material, and cost.

Fig. 15-3. Drawings describe parts precisely so that they can be made accurately.

Fig. 15-4. A prototype is used to test the design, the engineering, and the production methods.

The gears must be the right size. The *housing* (cover for the gears) must be strong enough and have the right appearance without weighing too much. The engineer may get information from the research and development group about the best components to use or the best material for the housing.

When the assembly has been designed, working drawings must be made for all the parts. Parts may be manufactured at company plants or bought from other companies. The drawings must show the correct *dimensions* (sizes) and *tolerances* (how much a part may vary in size and still fit with other parts). Otherwise, parts from different places will not fit together when they are assembled, Fig. 15-3.

The product design, the engineering, and the drawings are *evaluated* (tested) by building a *prototype* (working model). This is a single product made from the working drawings. Any *faults* (errors) in the design or in the drawings will be found in the prototype, Fig. 15-4. Errors are corrected by modifying (changing) the design or improving the drawings. The prototype may also give cost information.

The engineering department must supply other written information and drawings about the product. These include *instruction manuals* for the customer, *service information* for repair, and *warranties* which tell exactly how the product should work and how long it should last, Fig. 15-5.

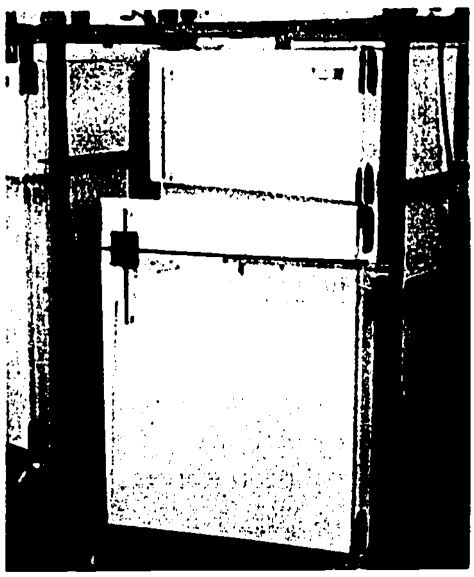


Fig. 15-5. To make sure they will last a long time, door hinges are tested by opening and closing the refrigerator doors thousands of times.

Importance of Product Engineering

No matter how attractive a product is, it will not continue to sell well if customers find that it does not *perform* (work) well. If elec-

IMPORTANT INSTRUCTIONS

READ BEFORE USING

General

Before plugging in unit, be sure your line and receptacle are sufficient for the amperage at which your Master Heat Gun or Master Air Heater Blower is rated and current is the correct voltage as shown on name plate.

Caution

Always keep front of nozzle at least 1″ from solid surface being heated, to prevent back pressure from building up in nozzle which will tend to burn out the heating element prematurely.

When turning off, it is advisable to switch from "hot" to "cold" and leave motor run a few seconds to cool the nozzle before shutting "off."

Handle gun with care. The ceramic heating element base is fragile and may break if gun is dropped or handled roughly.

To Adjust Heat

Heat is adjusted by turning the shutter knob on the air intake cover. Maximum heat is obtained by turning the shutter to close the air intake holes completely. The temperature range produced by your Master Heat Gun is based on use in normal room temperature. Temperature produced will vary from rating when used in extremely cold or hot conditions.

To Change Elements

To replace the heater element, remove nozzle and top housing, unscrew old element and replace with new one. Be careful to tuck wire between housing and field so it does not come in contact with the fan. Rubber washer must go under the element. Ease the nozzle back on straight so as not to break the element.

Warranty — Parts and Repair Service

This gun was carefully inspected before it left the factory and constructed to give long service. Should any defects show up within 30 days after it is put into use, return it to factory for prompt repair or replacement, at no cost. This warranty does not cover heater element if not used according to directions or if unit is damaged by accident, tampering or mishandling. Use the enclosed parts list for ordering replacement parts. Factory service is available. Ship unit by best way, prepaid, with repair order. Prompt repair service is given.

Master Appliance Corporation
1745 Flett Ave., Racine, Wisconsin 53403

Fig. 15-6. The engineering department must get instructions ready for the customer.

trical or mechanical parts fail too soon, or if the product does not work smoothly under most conditions, customers will soon stop buying the product. This is one reason why product engineering is important to the success of many manufactured products.

Another reason for the product engineer's importance is his skill with *detail drawings*. Good drawings are very important. Our *mass-production economy* depends on the manufacture of many parts exactly alike that will fit correctly with other parts. The producer of one part needs only the correct drawings for that part. For example, the manufacturer of the gears for an electric mixer does not need to know how they are to be used. If he has complete, accurate drawings of the gears, he can produce them in Ohio to be used in California.

Every automobile owner knows the importance of instructions and service information, Fig. 15-6. The owner would not get rid of a car just because the oil needs to be changed or the car has a flat tire.

Personnel

In many large plants, product engineering is given to a large engineering department or division, Fig. 15-7. Sometimes this same department takes care of research and development, product design, production planning, plant engineering, and production control. In small companies a single person may do all these jobs.

The different people in a product engineering group may not all have had the same schooling. Engineers nearly always have highly specialized training and college degrees. *Mechanical engineers* are trained to choose materials and to design power and mechanical parts, fastening devices, and other machine elements (parts). The work of many engineers is named in their titles. For example, there are *electrical, chemical, ceramic,* and *welding engineers.* All engineering college students must study mathematics, chemistry, physics, and communications (English, including listening, speaking, and writing), in addition to the courses in their special field.

The work of designing certain mechanical and power parts is often called *machine designing.* Machine designers may be engineers.

Technicians have training similar to that of engineers. They study less mathematics and physics, but they have more practical training. An electrical technician, for example, is better trained to wire a circuit than is an electrical engineer.

Drawings are often made by engineers and technicians, but the people specially trained for this work are *draftsmen.* If drawing is all they do, they may have only a high school education. They may also have training given on the job by the company for which they work.

A product engineer sometimes helps write instructions and service manuals. People with several other kinds of training usually combine their skills to produce the manuals: *writers, illustrators,* and *editors,* Fig. 15-8.

Fig. 15-7. Large companies hire engineers with different types of training.

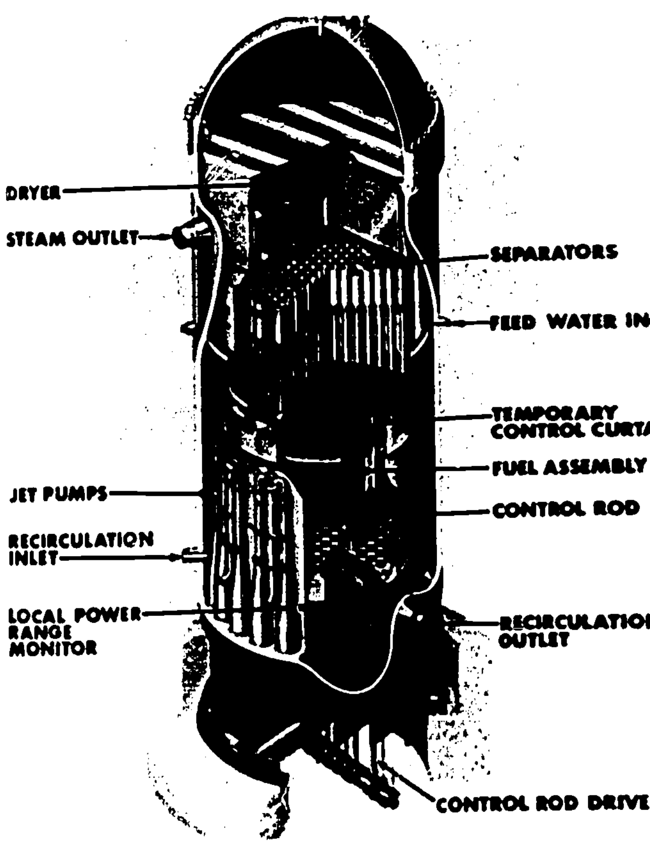
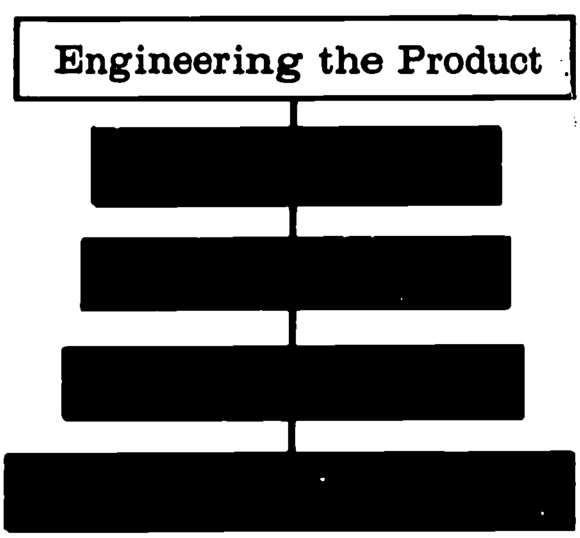


Fig. 15-8. Special talent is necessary to be a good illustrator. This is a cutaway rendering of a boiling water reactor.

These specialists all need to understand how the product works. A product engineer gives them *data* (information) or explains how a product works. He himself may do some of the writing. For a highly technical (*sophisticated*) product like a rocket, his job in writing manuals may be very important.

Summary

Product engineering completes the work of the product designer. Mechanical and power parts are chosen or designed. Drawings and prototypes are made. Instruction and service manuals are written. Engineers with different training work in product engineering. The engineers are helped by technicians, draftsmen, writers, illustrators, and other specialists.



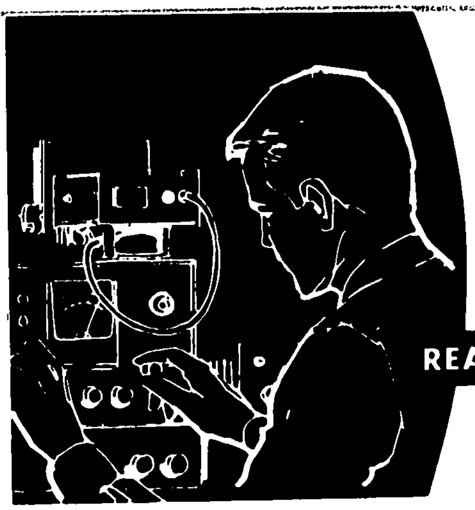
Terms to Know

function
product engineer
exterior
detail drawings
specifications
modified
elements
assemblies
interior
working drawings
prototype
technical writing and illustrating
housing
dimensions
tolerances
evaluated
faults
instruction manuals
service information
warranties
perform
mass-production economy
mechanical engineers
electrical engineers
ceramic engineers
chemical engineers
welding engineers
machine designing
technicians
draftsmen
writers
illustrators
editors
data
sophisticated

Think About It!

1. Why are *writers*, *illustrators*, and *editors* needed to help prepare service manuals?
2. What should you do if a wheel bearing on your bicycle failed before the *warranty* period on parts and service had run out? After it had run out?

Designing Power Elements



Suppose the product appearance has been decided on and approved. If there are any *internal* (inside) working parts, they must now be designed and engineered. The main work of the product engineer usually begins at this time. But even during the early stages of product design, he must think about internal parts, Fig. 16-1. Can you imagine what a power lawn mower would look like if the internal parts were not thought about when the *external* (outside) features were being designed?

One of the product engineer's jobs is choosing the exact location, size, and *horsepower* of a *power unit.* The engineer who specializes in this kind of product engineering knows a great deal about engines and motors. He knows a lot about the mechanical devices that *transmit* (pass along) power. He also works with mechanisms like tracks that carry a filing cabinet or desk drawer.

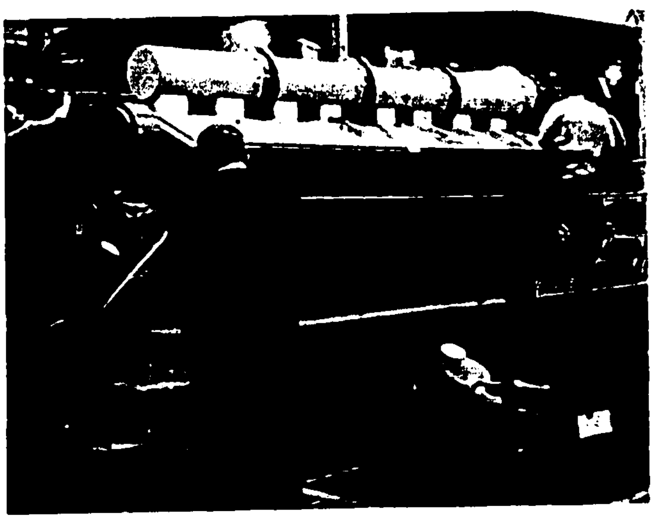


Fig. 16-1. It would be hard to design the locomotive that this diesel engine will drive without also thinking about the engine.

This reading will cover the steps in designing and engineering power units. You will also learn about the elements of an assembly that connect the power unit to the working parts of the product.

Determining the Power Requirements

The first step in designing a power unit is to find out how much horsepower is needed to do the work of the product. In a washing machine we have to find out the *maximum* (most) amount of power needed at any one time during an entire *cycle* (operation) of the machine. The engineer can figure this maximum power mathematically.

The next step in designing a power unit is to find out how much power is needed to overcome *resisting forces,* Fig. 16-2. For

Fig. 16-2. The power units in this log loader must be able to overcome all normal internal and external forces. To this must be added a safety factor amount for overload, emergency, etc.

example, several working parts of the product may come into contact with each other. When they do, a force is produced that slows down and wears out the working parts. This resisting force is called *friction.* We must overcome the friction between the parts that are transmitting the power from the motor to the working parts. These transmitting parts may be gears, belts, rollers, drive shafts, and other devices.

Finally, there must be power for *operating the controls.* An automatic washer uses power to operate several controls during the machine cycle. Some examples of these powered controls are: the opening and closing of valves, starting and stopping devices, timing devices, and warning devices. The power for these controls must be figured by the engineer.

Safety Factor

After the product engineer has figured all the power needs, he must next figure out the safety needs. If he built a machine with a power unit based only on the power needs we have discussed so far, he would be taking an unwise risk, Fig. 16-2. For example, if an elevator could lift ten people, the power unit could be designed for this load only, but this would not be very safe if twelve people got on the elevator. A *safety factor* (condition that makes sure the product is safe to use) must be built into the design.

A safety factor may be large or small. It depends on the type of product being designed. For a small hand drill, the safety factor is very low. When human lives are involved, as in airplanes, elevators, and automobiles, the safety factor must be very high. The engineer must build in enough extra power and strength to take care of a possible *overload.* For example, a four-engine airplane is designed and engineered to fly on only two engines in an emergency, after the other two engines fail.

A safety factor is some number greater than one. The normal power requirement is *multiplied* by this safety factor. For example, a ten-horsepower motor might be needed to run a machine, overcome internal friction, and operate the controls. If the safety factor for this machine is 1.5 ($1\frac{1}{2}$), a fifteen-horsepower unit will be used ($10 \times 1\frac{1}{2} = 15$).

Over-Engineering

Over-engineering means that the power unit put into a product is far greater than necessary, Fig. 16-3. This happens when the engineer builds in too large a safety factor or makes an error in *calculation* (figuring). Too much power is just as bad as too little power. More horsepower means a higher price for the power unit. It also means the customer's operating costs will be higher. The engineer must think about the cost of the power unit when he is designing the "right" size.

The Power Train

The *elements* (parts) that connect the power unit to the working parts of a machine are called the *power train.* Motors and engines often run at much higher speeds than

Fig. 16-3. The engineer should not over-engineer a product.

the speeds needed by the working parts, Fig. 16-4. In a washing machine, for example, there must be a system of gears, belts, levers, and pulleys to give a slow *reciprocating* (back-and-forth) motion to the agitator. Other gears and clutches are needed so the same motor can spin the tub at high speed to remove water. The product engineer must plan the power train for a new product. He may *modify* (change) an existing plan, or he may design a special one for the product.

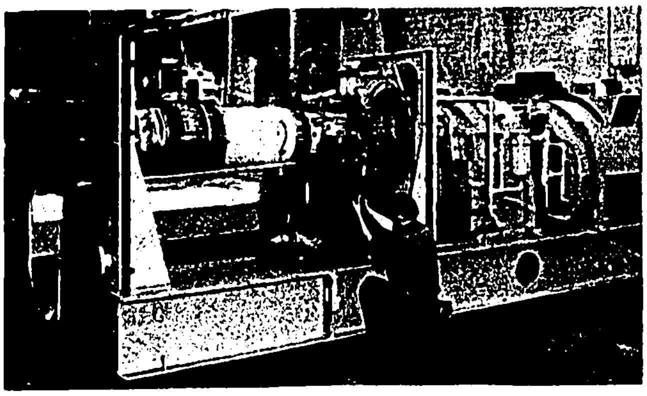


Fig. 16-4. This gas turbine-powered engine drives the generator through a reduction gear box.

Selecting the Type of Power Unit

The product engineer sometimes may have to *select* (choose) the kind of power unit. Should it operate on gasoline (Fig. 16-5), diesel fuel, or perhaps electric current (Fig. 16-6)? The engineer must study the costs of each kind of power to find out what type of unit will be the least expensive. Sometimes the choice is limited, Figs. 16-7,

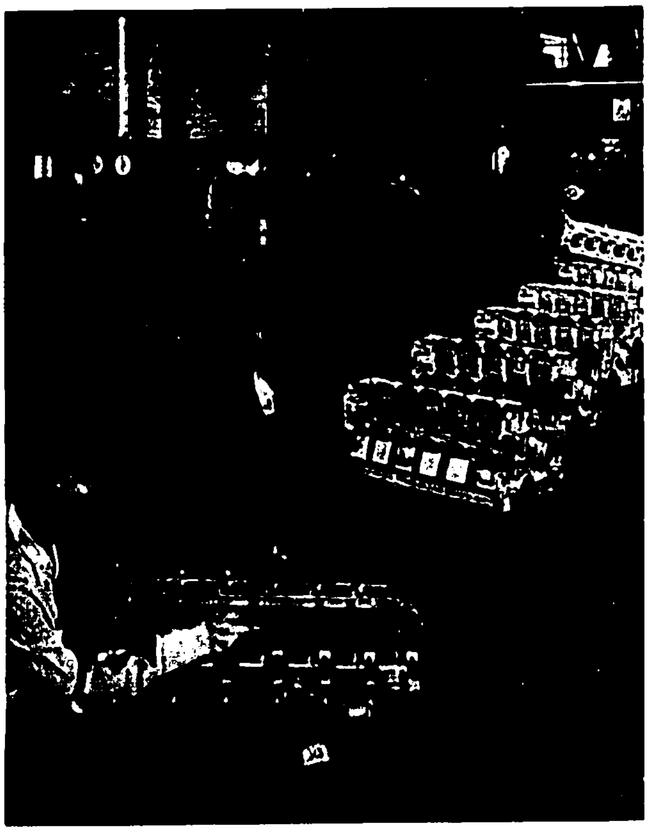


Fig. 16-5. This die-casting operation is producing six-cylinder gasoline engines.

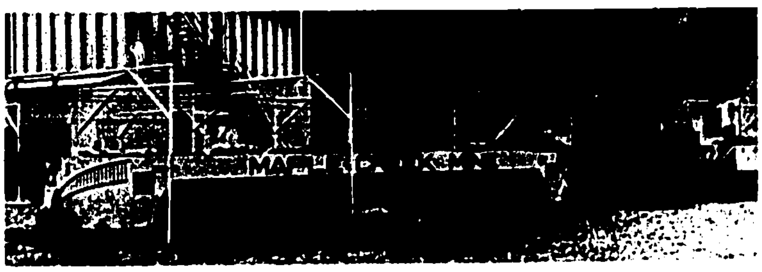


Fig. 16-6. Here we see a trainload of coal being pulled by an electric locomotive.

Fig. 16-7. Huge oil-burning engines are needed to move these barges through the water.

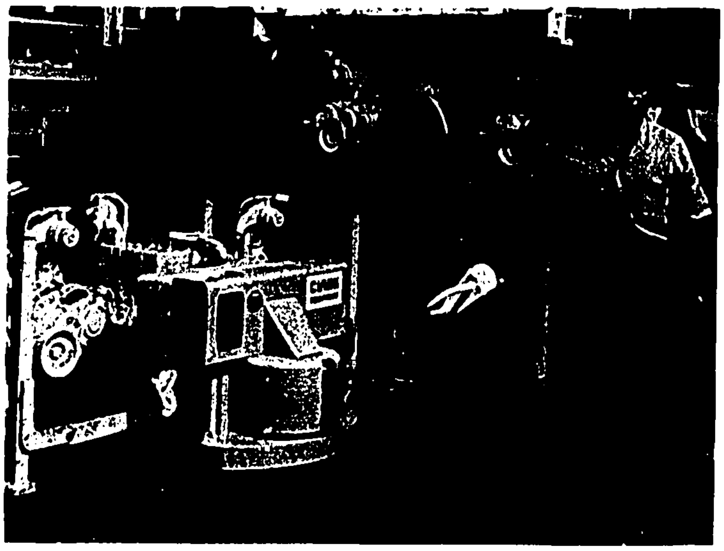


Fig. 16-8. This vehicle is powered by a rechargeable battery.

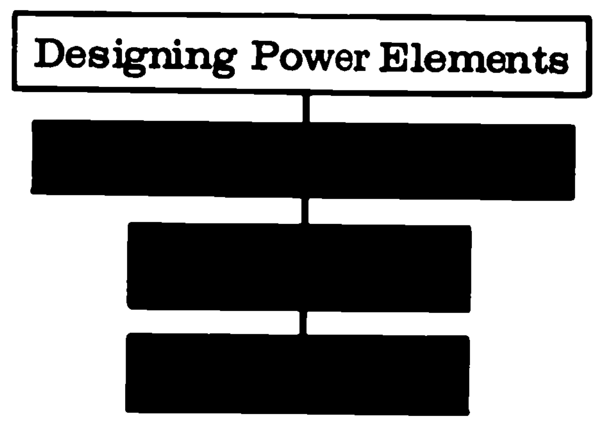
Fig. 16-9. Hand grinders may be powered by air.

16-8, and 16-9. For example, if a product is to operate in a wilderness where there is no electrical energy, an electrical power unit cannot be used. A similar problem can be found in some manufacturing plants. It may be impossible or unsafe to use a particular kind of power unit to do a certain job. The product engineer must know about such problems and know how to solve them.

When the engineer studies the costs of different designs, he thinks about two main kinds of costs. One is the combined cost of all tools, equipment, hardware, and installation. The other is the cost of operation, maintenance, repair, and replacement. By comparing costs, the engineer can select the least expensive design. For example, diesel engines are not often used in passenger automobiles because the engines cost so much. But they are often used for large trucks and buses since the lower fuel cost makes up for the high cost of the engines.

Summary

Many products like eyeglasses, wastebaskets, and coffee cups do not need power units. For those products that do, the product engineer completes the product design by engineering the working parts such as power units and power trains. The engineer must first find out how much power is needed to operate the entire machine through its cycle. He adds enough extra power to take care of any emergency. These figures tell how much horsepower the product needs to operate. The engineer then may have to choose between types of power units; for example, between an electric motor and a gasoline engine. Finally, he must locate the power unit (or units) in the product so that they take up the least amount of space and still operate at maximum efficiency.



Terms to Know

internal	safety factor
external	overload
horsepower	over-engineering
power unit	calculation
transmit	elements
maximum	power train
cycle	reciprocating
resisting forces	modify
friction	select
operating the controls	

Think About It!

1. How much of a *safety factor* has been built into your family's automobile? What features of the car increase the safety factor?

2. How would you decide whether an electrically operated football game should operate on batteries or house current?

READING 17

Making Working Drawings

Suppose a product has been designed. Drawings which describe the product are now made. They must be complete and accurate. They are called *working drawings.* Many groups work with them. The drawings help shop men to build the production prototype. Production planners and controllers study them as they get ready for production. Production workers use them when they manufacture and *assemble* (put together) the product parts.

Types of Working Drawings

Some manufactured products like gasoline, hair oil, shoe polish, and ice cream do not need working drawings. Their packages and containers need working drawings, but the products inside them do not. Most other products we use and handle each day are either (1) a single piece of material, or (2) a series of parts which have been assembled. A coin, such as a nickel, is a product which is a single piece of material. A bicycle is a product made of several parts which have been assembled.

Some products, like automobiles, have many parts and one or more systems, Fig. 17-1. A *system* may be thought of as a *closed* path through which something flows. An example is the electrical system of an automobile. Electric current flows through the system to operate the headlights, starter, engine, and radio.

You may think about the physical features of a product at three levels: single parts, parts assembled in groups, and systems. The drawings from which the product will be made must include all three levels. A set of working drawings includes: (1) drawings of individual parts, called *detail drawings;* (2) drawings of assembled parts, called *assembly drawings;* and (3) drawings of different systems, called *systems drawings.*

Detail Drawings

Detail drawings of a part must show its shape and give its size, Fig. 17-2. Detail drawings also include notes giving extra information.

Fig. 17-1. Most of the nearly 25,000 parts in an automobile need a separate detail drawing.

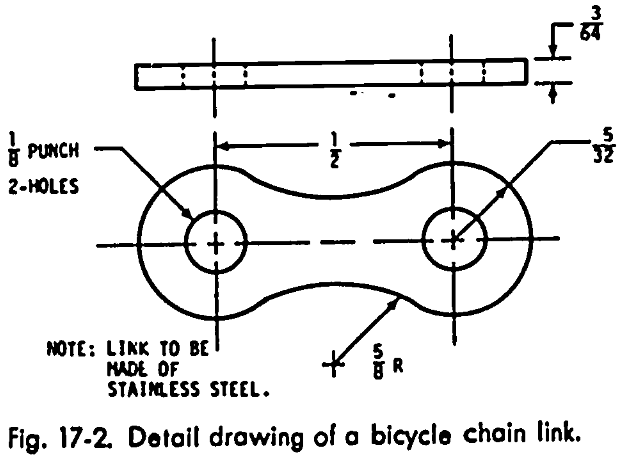


Fig. 17-2. Detail drawing of a bicycle chain link.

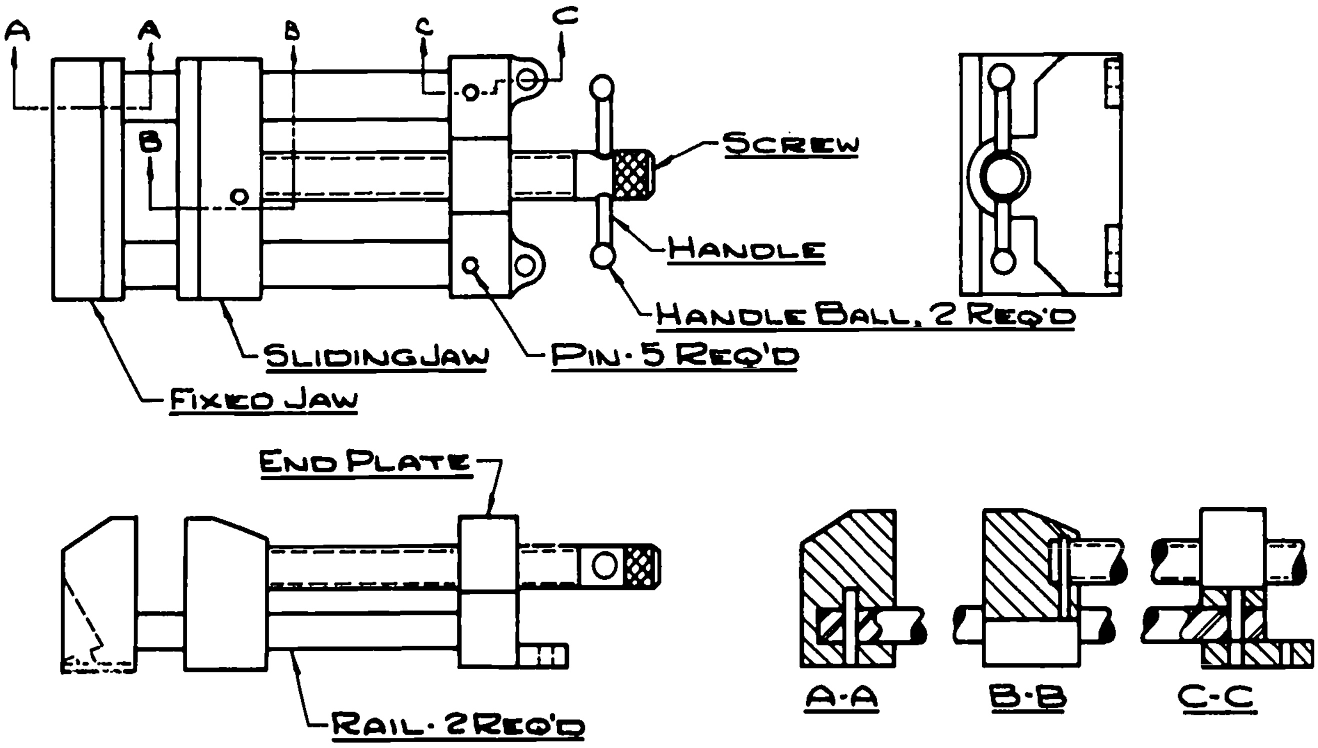


Fig. 17-3. An assembly drawing for a drill press vise.

The shape of a part is shown by drawing one, two, or several *views* of the part. Every solid object has three *basic dimensions*, often called *width*, *height*, and *depth*. Each view in a detail drawing shows only two of the three basic dimensions. Usually at least two views of a part are drawn. A drawing which shows two or more views is called a *multiview drawing*.

The exact *size* of a part is given by *dimensioning* (writing the basic dimensions on) the multiview drawing. The dimensions must give the overall size of the part, the size of every feature on the part, and the location of every feature on the part.

After a dimensioned multiview drawing has been made, *notes* must be added to finish the detail drawings. Notes include such information as: (1) the kind of material from which the part should be made, (2) how many of the part should be made, (3) what operations should be used in making the part, and (4) how nearly perfect the manufactured part must be made.

Assembly Drawings

Assembly drawings show how a product will look when all the parts are assembled. They may show how a major section of the product will look when it is assembled. They may also show *how* to put the parts together.

Assembly drawings may be multiview drawings, Fig. 17-3. They may also be *pictorial drawings*. Pictorial drawings show all three basic dimensions in a single view.

Assembly drawings often include *reference letters* (or numbers) which identify each part. Many assembly drawings include a *parts list* which gives the reference letter or number and the name of each part. They may also give dimensions to show where each part is located. Usually only a few important dimensions are given on assembly drawings.

Many products are so complicated that no one can understand a single assembly drawing of the whole product. Imagine a single drawing which shows all the parts of an

automobile assembled together! The drawing would look like a lot of meaningless lines. For a product with many parts, drawings are made for each of the main units, such as the transmission and engine. There will also be an assembly drawing of the *outlines* (basic shapes) of the main units and a set of assembly instructions.

Systems Drawings

Many manufactured products have one or more *systems,* such as an electrical or hydraulic system. Each system is usually shown on a separate drawing. Systems are usually not drawn as they really look! They are drawn as *schematic diagrams,* Fig. 17-4. This means that single lines and *symbols* (signs) are used to picture parts of the system.

Preparing Working Drawings

After the product design solution has been accepted by management, any needed mechanical and power details are worked out. Then working drawings are made. They are based on layouts, drawings, sketches, and notes of product designers and engineers. Working drawings are made in the engineering department by draftsmen, designers, engineers, or technicians.

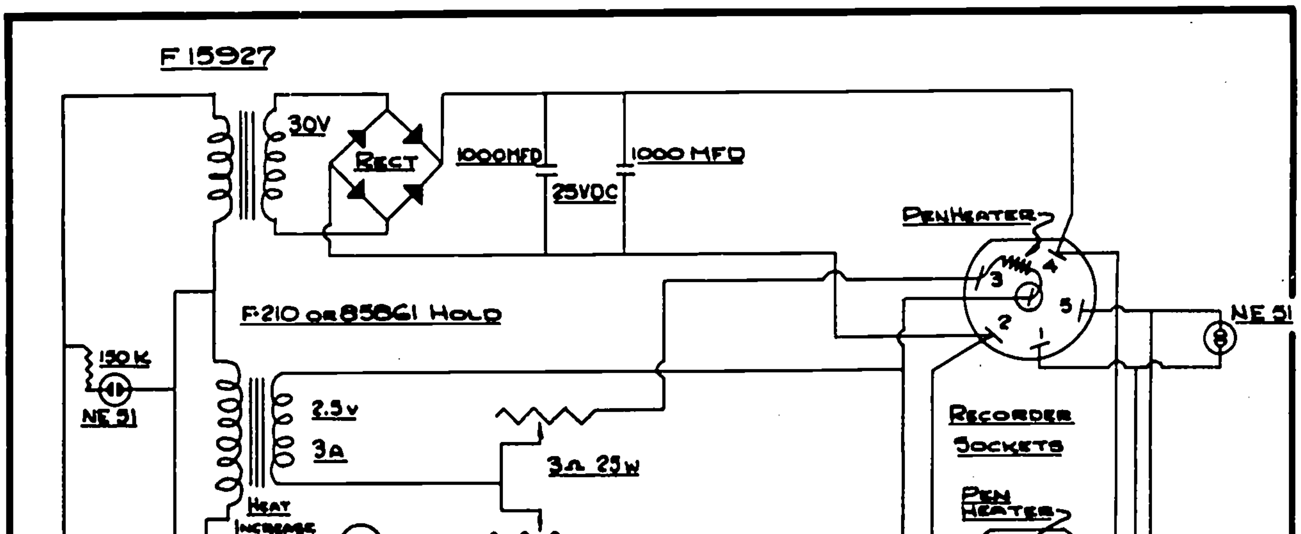


Fig. 17-4. Schematic drawing.

The draftsman prepares working drawings at a drafting table. *A drafting machine* or a *parallel straightedge* is usually attached to his table. The *original* (first) drawings are usually made with a special drafting pencil. They may be done on tracing paper, specially made papers, or plastic films.

Revising and Releasing Working Drawings

Supervisors check the original drawings. Then they are sent to a copy room where multiple *copies* (prints) are made. These prints will be used by the men who build the prototype, Fig. 17-5. They will also be used by engineers in production planning and control. Sometimes during this stage, errors are found or suggestions are made. Then the working drawings are *revised* (changed). Copies of the revised drawings are made and released for use. The working drawings are used by production workers, by all production control and quality control people, and by supervisors. Working drawings are important company records. The original drawings are carefully stored in case they are needed later on.

Fig. 17-5. A detail drawing for each part gives the dimensions of the part and how nearly perfect it must be.

Drawings for Outside Contracts

Sometimes parts or assemblies are made by other companies (*subcontractors*). Working drawings must be made for the parts or assemblies that will be subcontracted (made by other companies). First, a subcontractor is chosen and an agreement with him (*contract*) is reached. Then the drawings become part of the contract. This means that the company which got the order must make the parts exactly as they are shown on the drawings. Any changes in the drawings must be *renegotiated* (agreed upon again) by the two companies.

Computerized Drafting

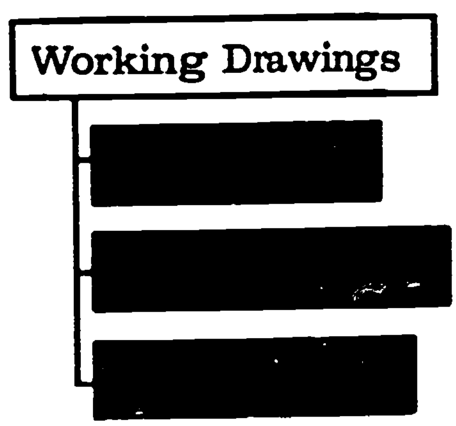
In the near future, working drawings will be made by *computerized machines* (machines run by computers). Drawings can be made today by these machines, but the machines are still being developed. Most drawings are still made by people at drafting tables with straightedges and pencils. As you can see, there will be a need in the future for persons who can *program* (write out the steps to be followed) the machines to make the drawings.

Summary

Working drawings are very precise descriptions of products. They are used by men who plan production as well as by men who make the product.

A set of working drawings includes detail drawings, assembly drawings, and systems drawings. Working drawings give information about shape, size, materials, and manufacturing directions.

Working drawings are prepared by draftsmen and other engineering personnel. In the near future, more use will be made of computers in making working drawings.



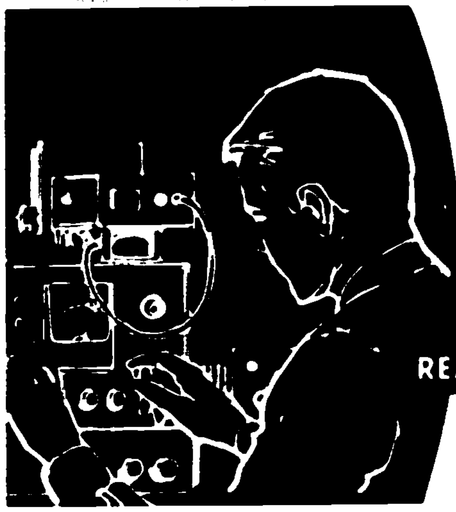
Think About It!

1. What products can you find in your home that are examples of
   a. a single piece of material?
   b. a series of assembled parts?
   c. a system?
2. Most model kits of airplanes, cars, or ships have *assembly drawings* to help you put them together. Examine one of these closely. How well does it fit the description of an assembly drawing in this reading?

Terms to Know

working drawings	reference letters	width	copies (prints)
assemble	parts list	height	revised
system	outlines	depth	subcontractors
detail drawings	schematic diagrams	multiview drawing	subcontracted
assembly drawings	symbols	size	contract
systems drawings	drafting machine	dimensioning	renegotiated
views	parallel straightedge	notes	computerized drafting
basic dimensions	original	pictorial drawings	computerized machines
			program

Building the Production Prototype



READING 18

Prototypes are built just before a final product design is chosen. They are tested and may be *redesigned* (done over again) before production plans are started. Both management and future consumers may look over prototypes before a final design is chosen. The designers and engineers use prototypes to test their product. Engineering and production personnel use them in planning their future work.

Nature of a Prototype

A *prototype* is a full-scale working model of a new product. It is built from working drawings. Testing the prototype may show that changes are needed, Fig. 18-1. Then the working drawings are *revised* (changed). *Revision* (changing) of prototype and drawings goes on until the design is ready for production planning.

Prototype units or *subunits* of a whole machine are often built before the whole machine is completed. Then tests can be run on each unit, and the results *analyzed* (studied), Fig. 18-2. If a redesign is needed, changes in one unit can be made while other units are being prototyped and tested.

Building Prototypes

Building prototypes is very expensive. The high cost is due mostly to wages paid to skilled craftsmen who make the prototype parts. Purchased parts used for the prototype also are costly. If these parts do not come in on time, it is very costly to have incomplete parts taking up important floor space in the factory. So, the *timing* (making sure parts are ready to be used on time) and the *scheduling* (making sure

Fig. 18-1. Prototypes of new airplanes are tested in the air for many hours before production.

Fig. 18-2. Sub-units may be built and tested separately before a prototype is assembled.

parts get from one place to the next on time) for the manufacture of prototypes are very important.

Usually, skilled workers make the prototype parts. They use general purpose machine tools and equipment. There are special manufacturing problems in building *one-of-a-kind parts* or units. They are also very expensive to make.

The prototype parts should be as much like the production parts as possible. A prototype with parts made by hand often works differently than one made from production parts.

Where parts must fit together (especially moving parts), *tolerances* and *allowances* are important. A *dimension* (size) that is off by a few thousandths of an inch may cause the prototype to work poorly, or it may even keep it from working at all. This is especially true for small working parts used in computers and business machines or in a car's automatic transmission.

While the prototype is being built, a record is usually kept of the changes made in parts. This is done so that the working drawings may be changed. Often a *quality control* or *quality assurance* group (those checking for poorly manufactured parts) *inspects* (checks) all prototype parts before they are assembled.

Fig. 18-3. Tests are made on new automobile shock absorbers to see how long they last.

Testing the Prototype

After the prototype has been built, it is tested by the men in the shop who built it. The *next* step is *acceptance testing* of the prototype. This is done by the engineering group who made the design. Very often the engineering group wants a number of different tests to be made either on the separate prototype units or on the complete product, Fig. 18-3. *Test results* (outcomes of each test) become part of the permanent record of each product design.

Preproduction Planning

Manufacturing problems of the prototype often become a part of the *preproduction planning* of the final product. Sometimes the prototype parts can be used for preproduction planning. This is done by scheduling the prototype parts:

1. Through a process planning group to decide on the steps to be taken (*sequence*),
2. Through a tool design group to find out what machines and *tooling* (special devices) may be needed for future manufacturing,
3. Through a *production control* group to set up schedules, and
4. Through a *time study* group to find out how much time is needed to make the parts.

The marketing and sales groups have a great interest in the prototype. They must show the product to future customers. Suppose the product is office machinery or dictating equipment. The groups must decide whether the consumer will accept its *performance* (how well the product does what it is supposed to do).

Comparing total cost with the suggested size of the market is often important. A prototype is useful to the research people. They survey the market to find out if future sales will pay for more developments.

Need for a Prototype

A good reason for making prototypes is to make sure that the planned manufacturing steps are followed. These steps use a set of drawings to make a finished product. The product must meet the needs of the customer. To make sure that all consumer needs are met, the prototype must be checked for *performance*, Fig. 18-4. If it does not perform, it must be *debugged*. Debugging means correcting all mistakes in the design and in the manufacture of the prototype.

A prototype also helps the manufacturing engineers make sure that the factory floor space and the machinery can be used for making parts, Fig. 18-5. Very often the actual making of prototype parts in the plant brings out unexpected manufacturing problems. Then, either new equipment or new planning is needed.

The appearance of a prototype is often changed. For example, on a sewing machine, lights with covers may be added to protect the operator from having an accident. Adding these lights changes the final design appearance of the sewing machine.

Fig. 18-4. This prototype of a space capsule ejection parachute is tested on a dummy to see if the parachute will open.

Human engineering (making the product so that it can be handled or used by people) needs prototype testing. Suppose the product is a machine and the operator must push buttons. Testing may show that the buttons are too far apart. Levers may be too hard to push or pull. The height from the floor may force an operator to stoop or stretch.

Field Testing the Prototype

Suppose the manufacturer has built, tested, and tried out his new model of a product. Then he lets some customers actually use it in the way the product itself will be used (*field tests*), Fig. 18-6. This is per-

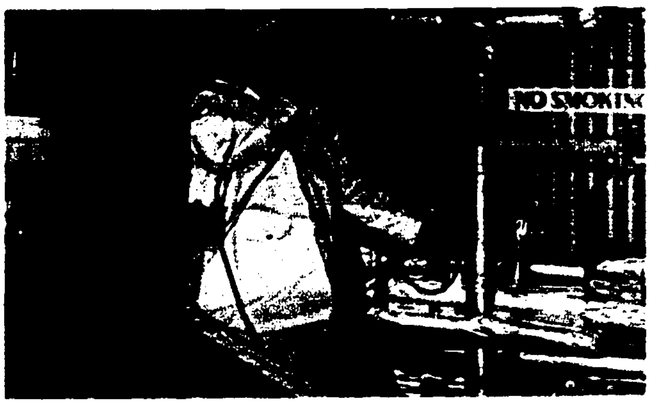


Fig. 18-5. Possible production problems are often solved by *pilot plant* operation, in the process industries, before full-scale plants are built. This is part of the equipment in a pilot plant which makes use of a hydrogen-amine exchange process in the production of heavy water.

Fig. 18-6. Safety of new products must be tested. Hand soap is tested for mildness.

haps the hardest test that the prototype will get. If a product passes field tests and is accepted by a normal sampling of customers, then full production can start.

Summary

Prototypes are full-scale working models of a product. They are made to test performance and consumer acceptance and to help solve production problems. Information found in testing the prototype is used to get ready for production.

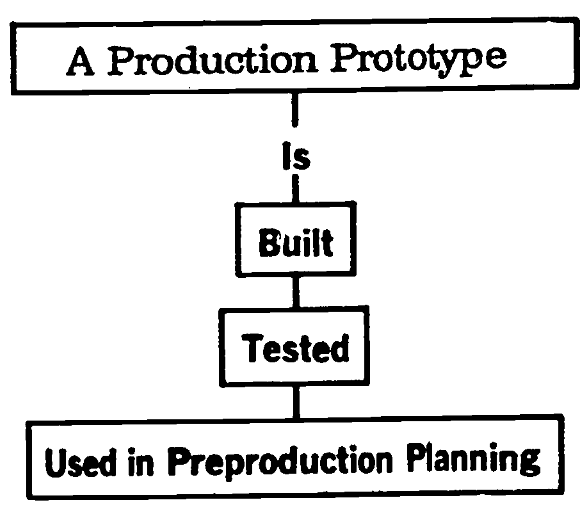
When changes are made on a prototype, the working drawings are corrected to show these changes exactly. A prototype model and the drawings may be studied by many groups in the manufacturing plant. The manufacturing engineers use prototypes to choose processes or to plan floor space.

Terms to Know

prototypes
redesigned
revised
revision
subunits
analyzed
timing
scheduling
one-of-a-kind parts
tolerances
allowances
dimension
quality control
quality assurance
inspects
acceptance testing
test results
preproduction planning
sequence
tooling
production control
time study
performance
debugged
human engineering
field tests

Think About It!

1. Why would management or future consumers want to look at *prototypes* of products before final designs are chosen?
2. Do you think there was ever a *prototype* of this book? Was it *field tested?* Have you found any *bugs* in it?



Technical Writing and Illustrating

You have seen how an idea is developed into a design solution. You have followed the steps leading to the decision to manufacture the product. While production is being planned, *technical writers and illustrators* also start an important job.

Product Information

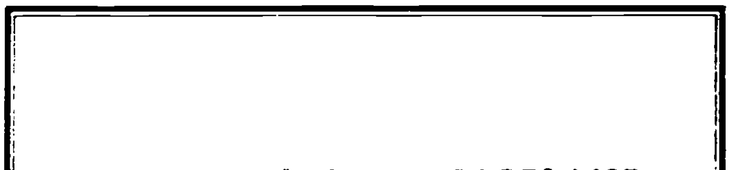
Technical writers put into words many kinds of information. For consumers, they write about the product and how to handle it. They may write:

1. *Unpacking and assembling instructions,*
2. *Operating instructions,*
3. *Safety precautions,*
4. *Emergency steps,* and
5. *Maintenance steps.*

Not all of these are needed for every kind of product. One page of instructions sent with a food mixer may be enough. A machine tool or printing press may need several books (*manuals*) to cover all the needed information.

The manufacturer gives *instructions* (written directions that tell how to put together and use the product) to help the buyer, Fig. 19-1. The customer who follows instructions closely should get the best performance from the product, for the longest possible time, with the fewest repair bills. This customer brings few problems back to the manufacturer. A customer who is well informed about the product seldom needs help. *Instruction manuals* must inform the customer about the product.

Since it is very hard (maybe impossible) to design a product that will not cause injury through misuse, *safety precautions* (warnings) point out dangers to the people who work with a product. Precautions about correct use often are stressed in the instructions. Warnings may appear on plates fastened to a product near the danger area. This information is given to keep the customer from harming himself or the product.


INSTRUCTIONS AND PARTS LIST
OF THE
C
BOSTITCH STAPLERS

When in need of Parts or Service
Contact Your Bostitch Distributor.
You will find "BOSTITCH" listed in
phone books of most large cities.

Fasten It Better and Faster
with BOSTITCH
STAPLERS AND STAPLES

Fig. 19-1. Every product that must be assembled needs instructions. Every product that will need replacement parts also needs a parts list.

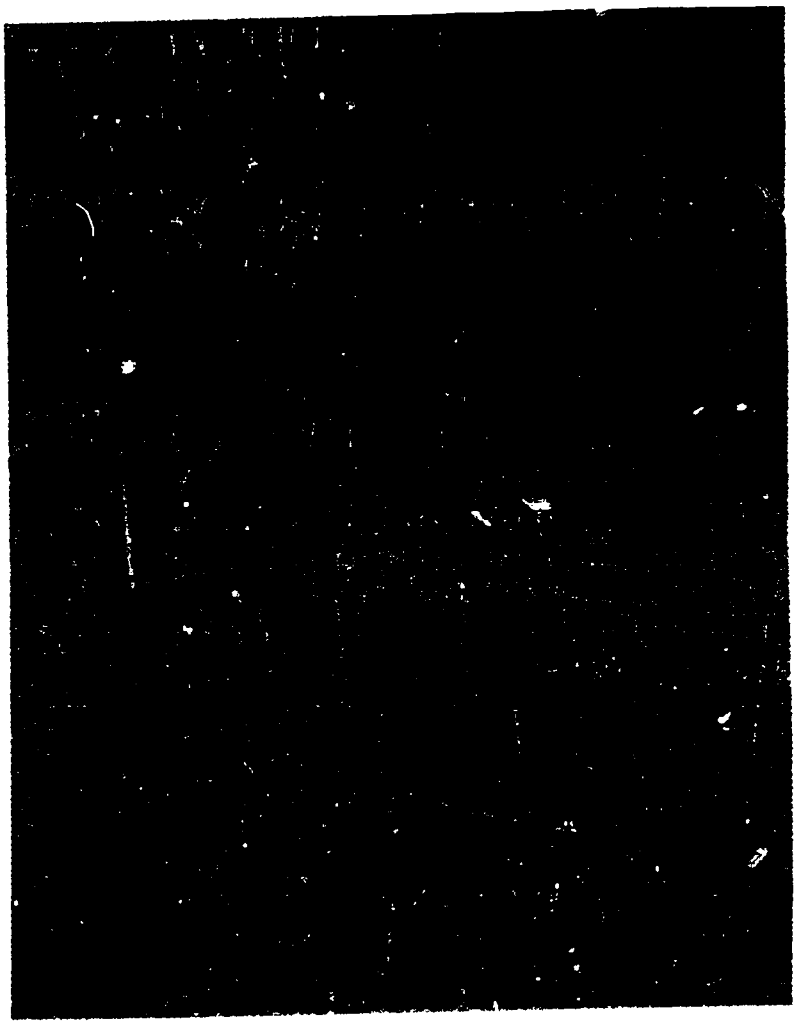


Fig. 19-2. Product information for customers may be written in an advertising department.

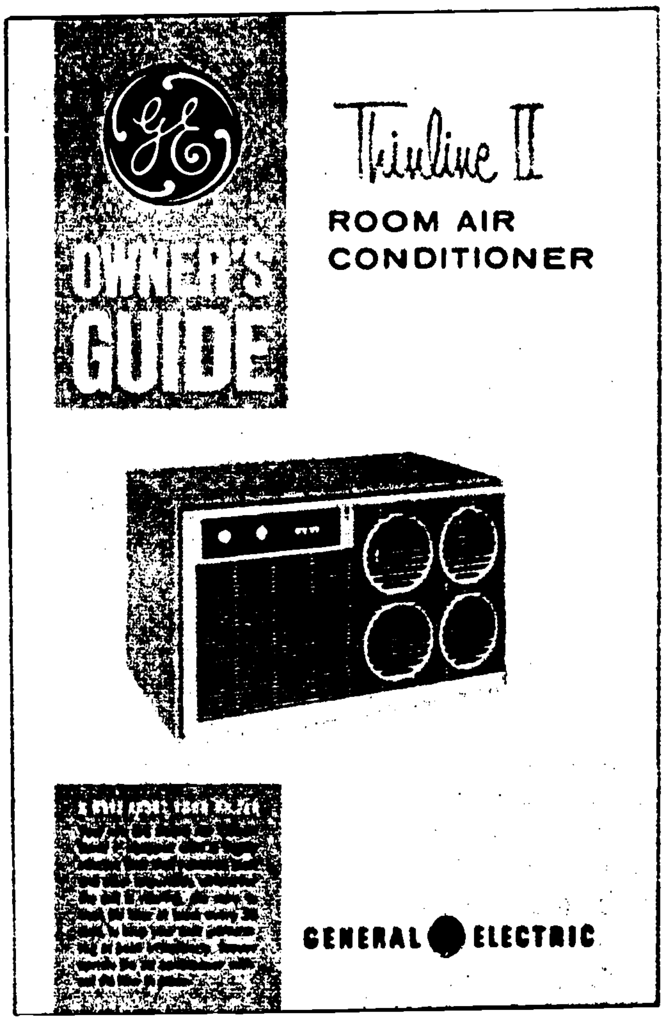


Fig. 19-3. Technical writers and illustrators prepare manuals that give operating instructions and safety precautions.

The Technical Writer

A technical writer may be an engineer or technician who can write well. He may be a writer who understands technical things. In some companies, he works in the engineering department. Here he can be near the designers and engineers who have technical information. In other companies product information for customers is written in the advertising department, Fig. 19-2. In these companies the writer is closer to the customers, so he is better able to decide what the customers need. Some small manufacturing companies do not hire writers. They *subcontract* the work with companies that do technical writing for others.

Writing for the Customer

As soon as management approves a new product, the technical writer's work begins. All instructions and precautions should be ready, in printed form, when the first products are ready for shipment, Fig. 19-3.

Information must be written so that it is *simple* and *clear*. The customer needs to understand the explanations, but he may not know the engineer's technical language. Complicated sentences and technical terms may confuse him.

Instructions for installing, operating, and maintaining the product must be *accurate*

and *complete*. Service manuals should list all the product parts. For standard parts, such as nuts and bolts, sizes are given so that the customer can buy them at a local hardware store.

The terms of the *product guarantee* or *warranty* (promising satisfactory performance) should be included. The manufacturer's legal department helps write this statement, Fig. 19-4.

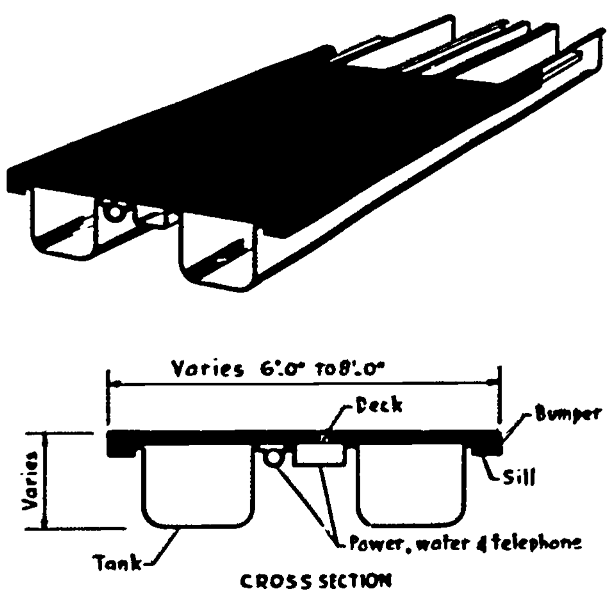
Technical Illustrating

No matter how well it is done, writing cannot completely describe *most* products. Illustrations must be added to make an instruction manual useful, Fig. 19-5. *Illustrations* include photographs, sketches, diagrams, or drawings chosen to picture an idea.

For complicated products, engineering drawings are needed. These are specially made drawings or artists' sketches to show up hidden parts, Fig. 19-6. Special drawings and sketches may use any of the techniques used by *draftsmen*. For products used in the home, pictorial *exploded-view drawings* (parts spread apart) are very useful.

Fig. 19-4. A warranty promises satisfactory performance. It must be written very carefully.

Illustrations may be drawn by draftsmen. For illustrations beyond the skill of a draftsman, an illustrator or artist may be needed,



ALUMINUM COMPANY OF CANADA.LTD

Fig. 19-5. This is an illustration of a floating aluminum dock.

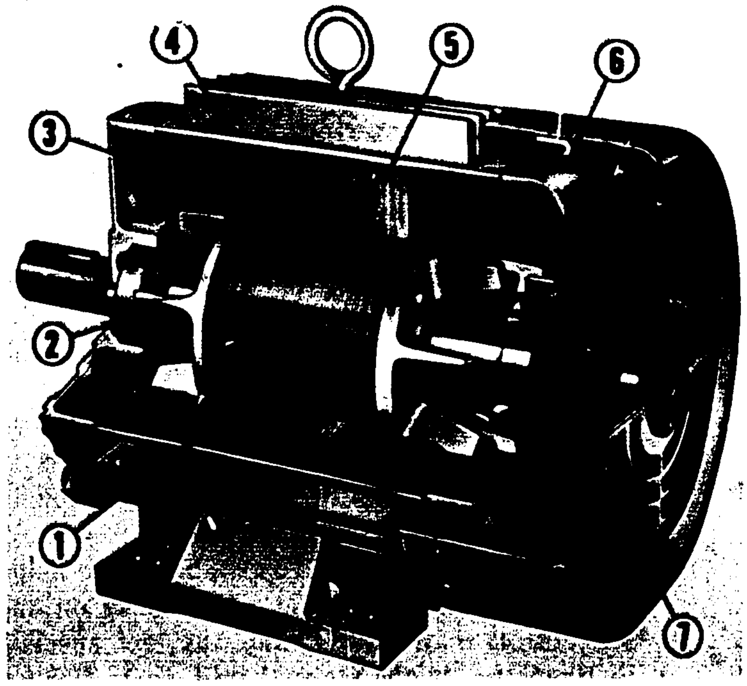


Fig. 19-6. This is a cutaway drawing of an AC motor.

Fig. 19-7. Some companies have their own technical illustration department. Others have their work done by commercial studios. The illustrator works closely with a technical writer who decides which parts of the writing need illustrations.

A draftsman may redraw the company's own working drawings for use in a manual. He will take out dimensions and other production information. He will leave in only the lines that show how to operate or service the product, Fig. 19-8. Artists or illustrators make pictorial illustrations from engineering drawings. They retouch photographs to block out background and highlight details. They use air brushes and other specialized equipment. Their purpose is always to do illustrations that will make the written text clearer, Fig. 19-9.

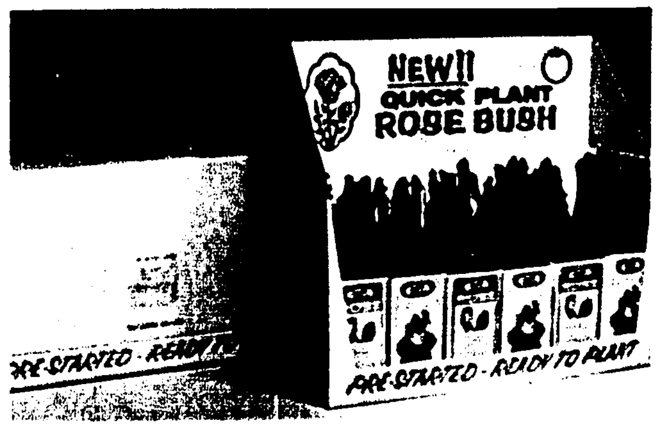


Fig. 19-7. Illustrations are needed on shipping containers that will be changed into displays.

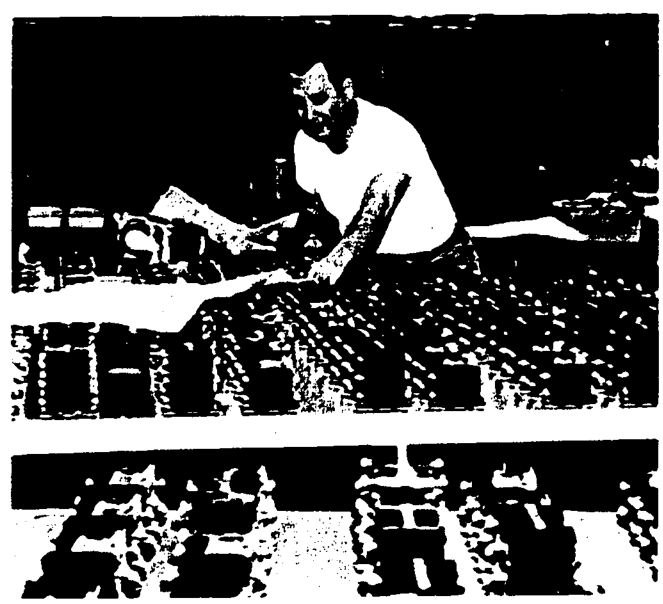


Fig. 19-8. An illustration may be designed for use by workers who assemble or service the company's products.

Technical Editing

An instruction manual (booklet) must be designed and engineered. The processes for manufacturing it must be well chosen. A technical *editor* often does these highly specialized jobs.

An editor may specialize in *simplifying* writing, Fig. 19-10. He may receive a *manuscript* (a piece of writing) which has many technical terms from chemistry, electronics, or hydraulic engineering. In this manuscript there will be instructions which must be given to readers. But the readers may not understand the language of the engineer. The editor *translates* (rewrites) the message so that the readers will understand it. To do this well, the editor must have both technical knowledge and writing skill.

Along with simplifying, an editor may *slant* a manuscript; that is, he may write it for a certain group of readers. He should know if a product is going to housewives, students, or stenographers. This will help him choose his words when he works on an instruction manual. He may suggest special illustrations, if the manual will go to a special group of consumers. Like any other designer, he plans his product to meet consumer needs.

If a manual (booklet) will be several pages long, the editor may make a rough paste-up (*dummy*). Each dummy page shows what will appear on each manual page: printed matter (*text*), drawings, or charts. A dummy shows how much space can be used. The editor can then plan the best possible use of illustrations and text.

Some technical editors help to choose the information which goes into manuals. Others

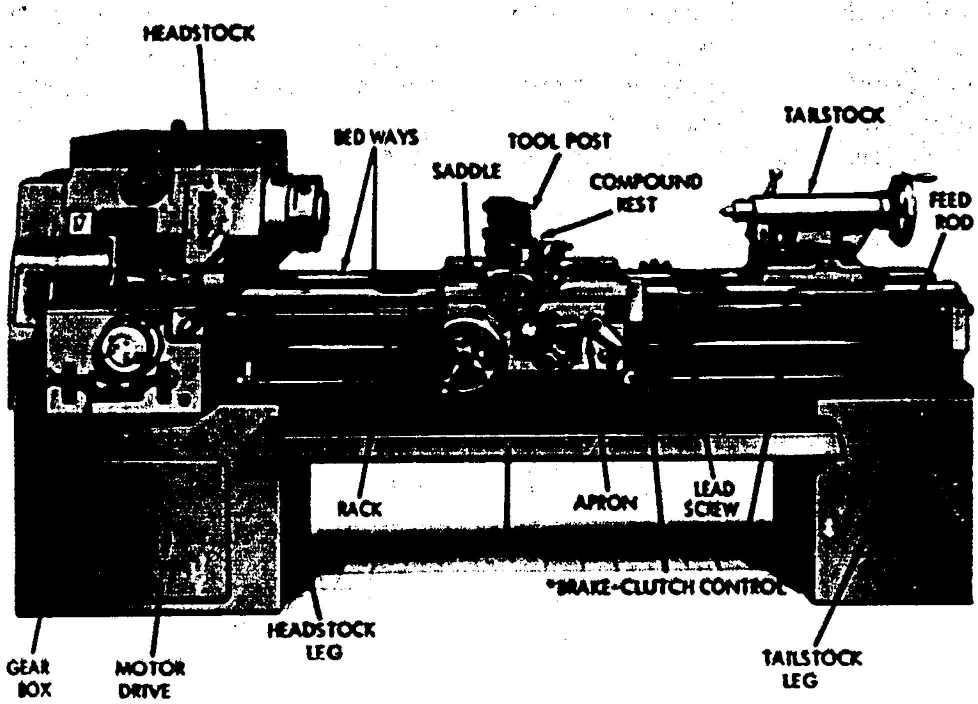


Fig. 19-9. This illustration shows the location of the different parts of a lathe.

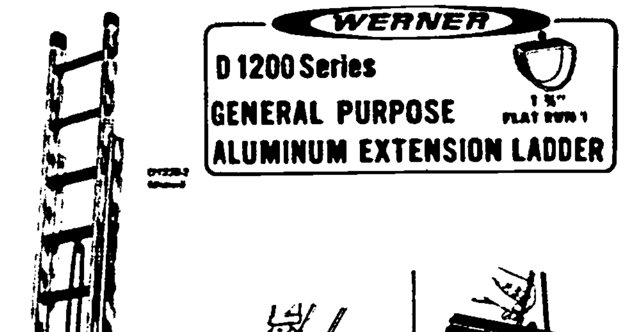


Fig. 19-10. An editor must simplify technical writing so that the people who use the product can read its instructions.

specialize in arranging the information attractively. No matter what else he does, the editor is supposed to correct wrong spelling and wrong punctuation.

Some companies print their own consumer manuals. They also print their own technical reports, price lists, and other printed matter. Here an editor needs to know about printing processes, paper, ink, and ways of binding booklets. If manuals are printed somewhere else, a printer usually gives the editor suggestions about appearance, printing costs, and good ways to use colored ink.

A technical writer may do most *editing* tasks. A technical editor may write large sections of a manual. Companies divide the writing and editing work in many different ways. For writer and editor, technical knowledge and writing skill are needed.

Reporting within the Company

Many company workers must report their activities, decisions, or other information in writing. These people are not called writers,

kind to someone in another department who may use it in a report to a customer. Some reports are simple messages between offices. Others are highly technical, formal, and detailed. Report writing is a necessary job for most people in management.

Writing Specifications

Buyers of consumer goods such as home appliances and automobiles care most about appearance and performance. They usually do not care much about construction details or the materials used. But manufacturers usually need precise descriptions of these details, called *specifications*. Specifications may ask for a certain *performance* from a product. They may ask for *physical qualities* like material or size. For example, the manufacturer of an automobile may buy bolts from a bolt manufacturer. The buyer may specify that the bolts must have a certain strength (*performance*). He may also specify *dimensions, tolerances,* and the type of steel to be used.

Specifications protect both buyers and sellers. They make the buyer sure that products will work right. The seller knows that if his product has the specifications the buyer asked for, the buyer will be satisfied. Safety is often important to think about in writing specifications.

Specifications may be set by either buyers or sellers. Most industrial specifications for parts are written by engineers or technicians. They know exactly what the part must do.

The military services and other government agencies often make detailed specifications for products they buy. They often state the size, the materials to be used, and how the product performance is to be tested, so they can buy from different sellers and know they will get what they need.

Much detail needed in specifications does not have to be written down. Some specifications have been set up by different industrial and government groups. These groups include the *American Standards Association,*

but they need writing skill. For example, *research engineers* write a great deal. Their experimental and developmental work cannot help management unless it is reported and written so management can understand it.

As companies grow larger and manufacturing becomes more complicated, a great deal of *correspondence* (writing) is needed. A worker may write one kind of report to a co-worker. He may write another kind of report to his supervisor. He may write a third

the *American Society for Testing and Materials,* and the *Bureau of Standards.* If the product has followed the specifications of any of these groups, very few details have to be written down. For some products, specifications set up by the *Fair Trade Commission,* the *Federal Drug Administration,* or the *Department of Agriculture* must be followed in order to protect the public from poorly made products.

Summary

Technical writers write about products for customers. They tell how to assemble the product, operate it, and maintain it. People with both engineering knowledge and writing skill are needed for this work.

Illustrations provide information that cannot be given in words. Draftsmen, illustrators, and artists draw illustrations.

Technical editors design and engineer instruction manuals for special consumer needs. They rewrite technical language so that the nontechnical consumer can understand it.

A worker in any *phase* (stage) of company work may need to write reports to other workers in the company. If his work is technical, some of his writing will be technical too.

Specifications describe a product and its performance so that both the manufacturer and his customer will know what a product is supposed to do. Specifications help to make sure that both the buyer and the seller will be satisfied with the product.

Technical Writing and Illustrating

- [redacted]
  - Prepare
    - Unpacking & assembling instructions
    - Operating instructions
    - Safety precautions
    - Emergency procedures
    - Maintenance instructions
- [redacted]
  - Illustrate manuals with
    - Sketches
    - Detail drawings
    - Assembly drawings
    - System drawings
    - Photographs

Terms to Know

technical writers and illustrators
unpacking and assembling instructions
operating instructions
safety precautions
emergency steps
maintenance steps
manuals
instructions
instruction manuals
subcontract
product guarantee
warranty
illustrations
draftsmen
exploded-view drawings
editor
simplifying
manuscript
translates
slant
dummy
text
editing
research engineers
correspondence
specifications
performance
physical qualities
dimensions
tolerances
American Standards Association
American Society for Testing and Materials
Bureau of Standards
Fair Trade Commission
Federal Drug Administration
Department of Agriculture
phase

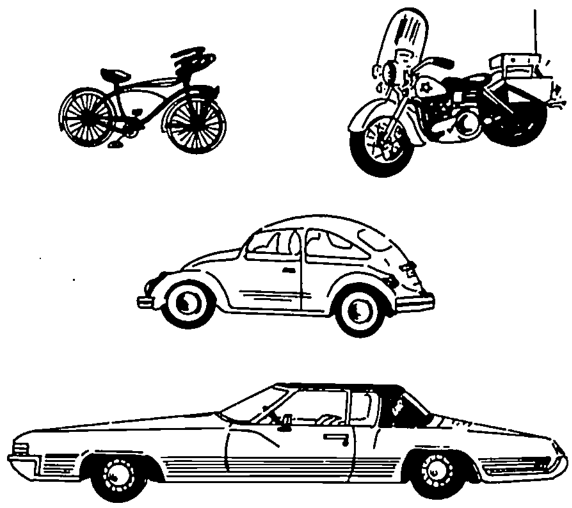
Think About It!

1. Ask your parents for a service manual or a set of instructions that came with a recent appliance purchase. Is the manual easy to understand? Can you follow every instruction quickly and easily? Do you find the illustrations helpful? Are the illustrations more helpful than the *text* (printed instructions)?
2. Look at the *warranty* for one of the appliances in your home. What information does it give you?

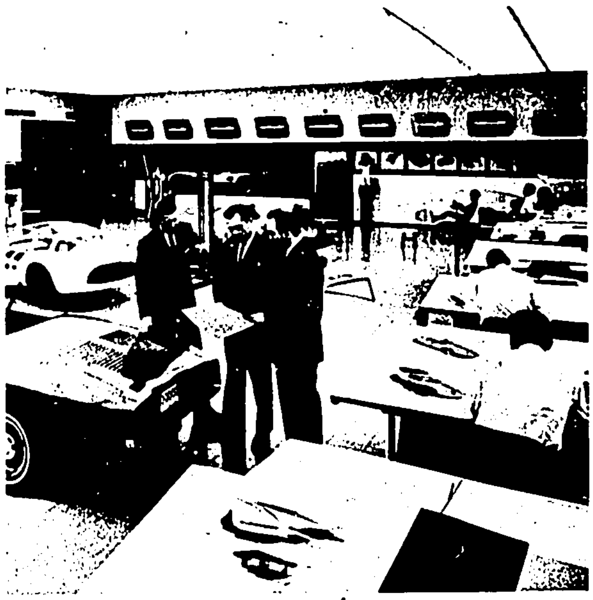
Basic Management

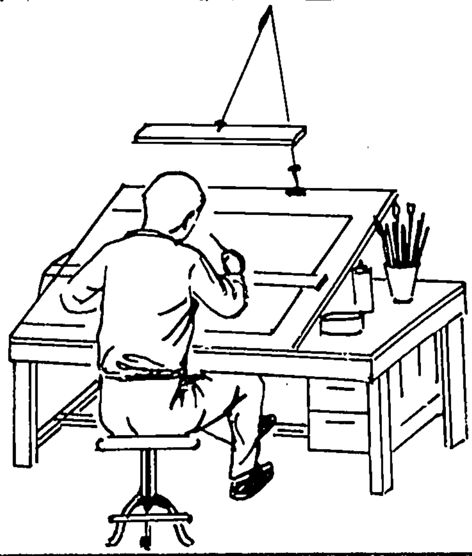
Man Plans,

Identifying Consumer Demands

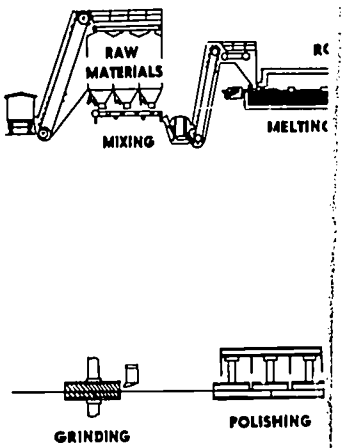


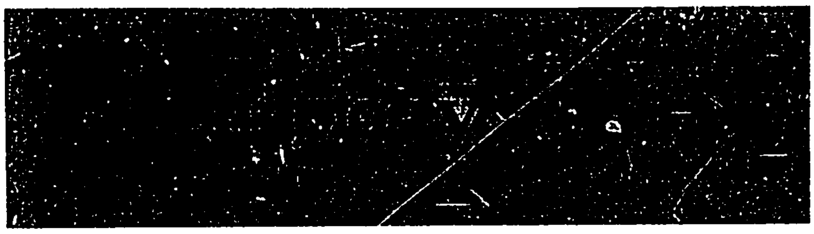
Designing Manufactured Goods





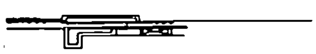
Planning



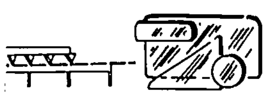


. . Organizes, ... and Controls Production

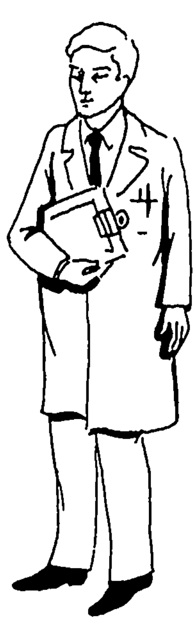
Production



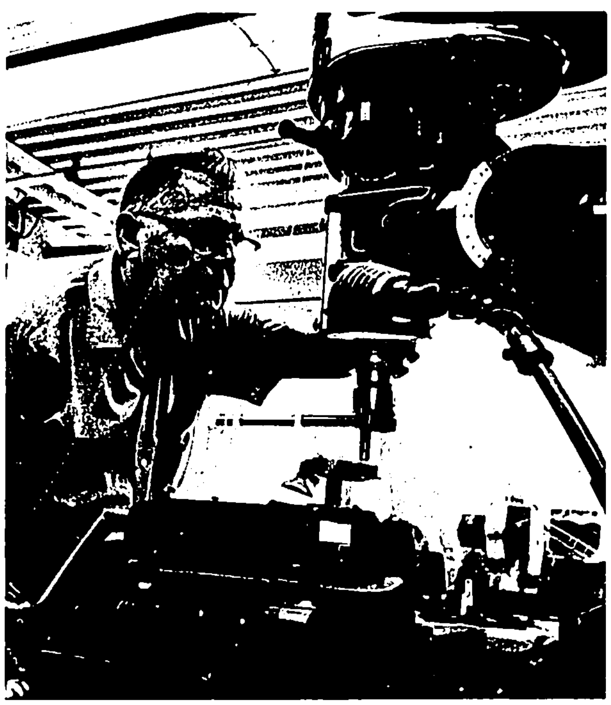
ANNEALING



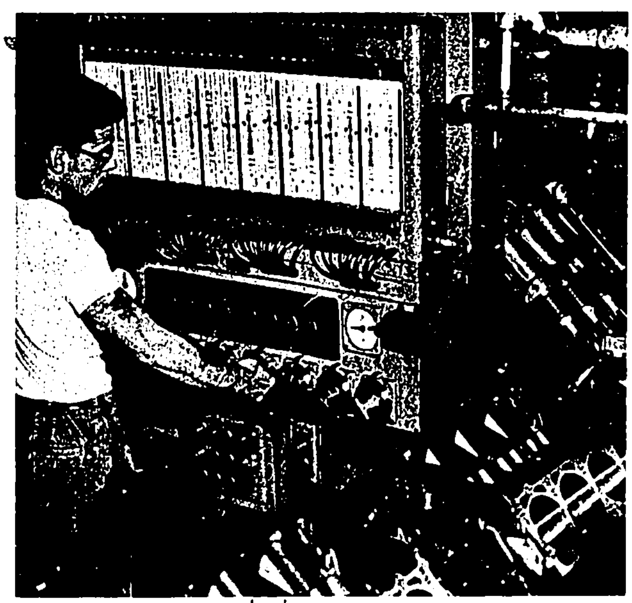
:UTTING FINISHED PRODUCT

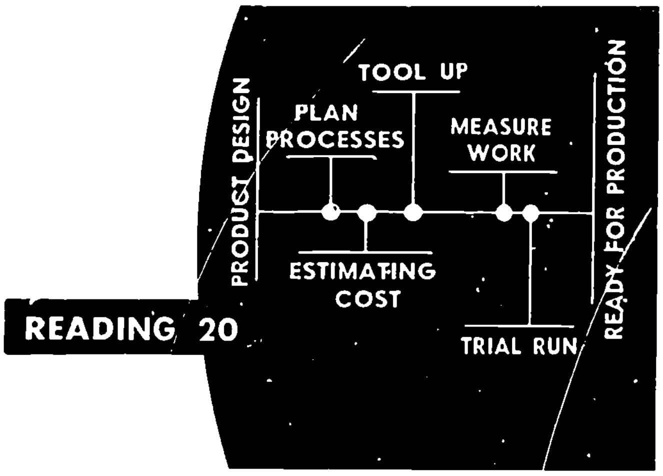


Tooling Up for Production



Establishing Production Control Systems





Planning Production

History shows that man has always looked for better ways to make things. Even the caveman learned that some rocks were better for making tools than others. He also learned that some people made better tools than others. The caveman learned by trying one thing and then another (the *method of trial and error*). In this reading, you will learn about two management groups that look for the best production processes and methods. In later readings, you will study the techniques that these groups use. Some of their techniques are process or methods study, work measurement, cost estimation, and automation. These management groups are often called *industrial engineering* and *manufacturing engineering.*

The Manufacturing Engineering Group

The size of the manufacturing (production) engineering group depends on the size and organization of the company and on what products the company makes. Usually, the manufacturing engineering team has two main kinds of engineers. In your reading you will find the terms *manufacturing engineer* and *industrial engineer*. They do many kinds of work. Their titles and even some of the jobs they do differ from company to company.

The *manufacturing engineer* improves the *producibility* (the company's ability to make something) of product design. He also plans the ways of manufacturing. He develops tools and machines. Finally, he makes sure all tools and machines work together for smooth production. The *industrial engineer* designs, improves, and *installs* (puts into use) systems of men, materials, and equipment so that they all work together. He is in charge of the safety and working conditions of the workers. He must see that time schedules for ordering materials and equipment, performing operations, and shipping products are planned and achieved. Above all, the manufacturing engineering group must see that these jobs are done in the best way.

Working together, this team plans most of the things necessary for efficient production. They must choose the processes which can produce the product. The industrial engineer sees that people are used in ways that are most efficient.

There is a great deal of competition among manufacturing industries, Fig. 20-1. The manufacturing engineering group and the product designer try to make sure that

Fig. 20-1. The companies which can produce products most efficiently make the biggest profit and grow the fastest.

the company's products will be better than its competitor's. They also want to be sure the products can be sold at lower prices and still make a profit. *Productivity* (ability to produce goods) and wages have improved in the United States. The standard of living in the United States has also gone up steadily, Fig. 20-2. Working conditions have improved, people work fewer hours, and profits have gone up.

The *process engineer* must choose the best machines, equipment, and processes for manufacturing. The *methods engineer* finds the best way for people to work at the machines and to handle the product. *Tool engineers* design any special equipment or attachments that are needed to make a standard machine ready for production, Fig. 20-3. Many manufacturing machines are built in an incomplete condition, so the tool engineer must design tools, holding devices, and handling equipment for each production job. The *work measurement engineer* or technician finds out how long each operation should take.

Manufacturing engineering people also work closely with people from other departments. The accounting department gives them information on costs so that the most efficient way may be found. The product designer uses the information he gets from the manufacturing or industrial engineer. He does not want to design products that cost too much to manufacture. A plant designer must work closely with the industrial engineer so that the plant layout will make production smoother. The foremen and production workers work closely with the engineer so that his decisions will be carried out correctly.

Manufacturing Engineering

The basic problem in designing and engineering production is like that in other kinds of engineering. The engineer must always look at many possibilities in order to choose the best ones. Even when a new product is designed, choices are made which will affect the manufacturing processes and costs. For example, an automobile body may be designed with steel fenders or with reinforced plastic fenders. The manufacturing proc-

Fig. 20-2. With less labor needed for production, wages have gone up more than prices. Increased productivity has given us a higher standard of living.

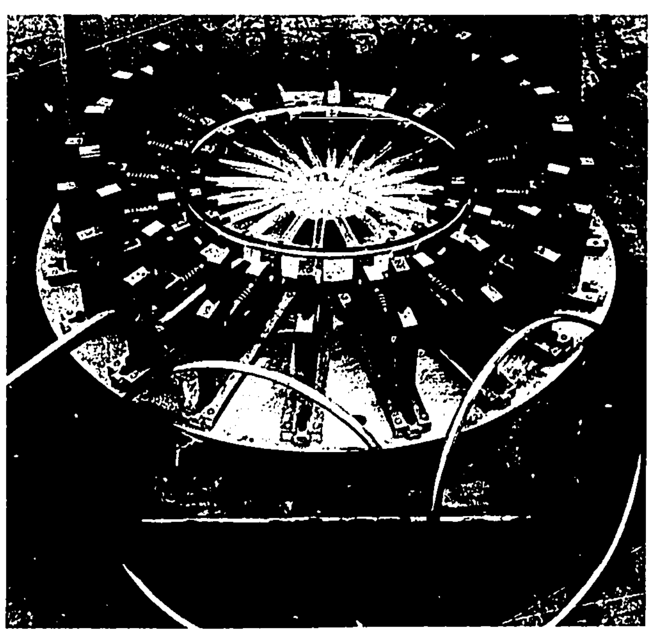


Fig. 20-3. Tool designers must often design and have built special handling equipment before a machine can be used for production.

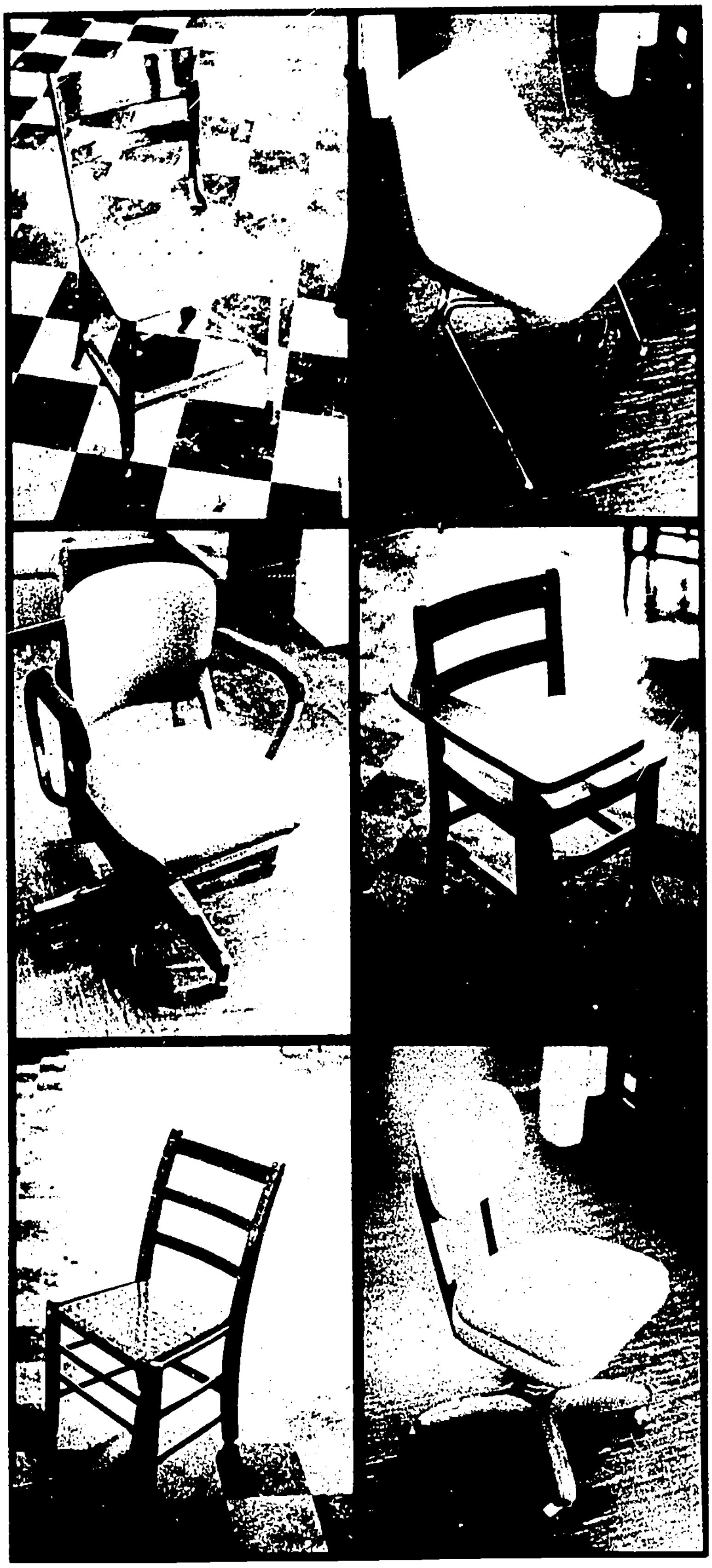


Fig. 20-4. These products all do their job equally well. Because they are made of different materials, different processes must be used for their manufacture.

esses are completely different for these two materials, Fig. 20-4.

Suppose the design is chosen. Before the product can be made, the manufacturing engineer must look at several processes or machines for doing the operation, Fig. 20-5. He then chooses which one to use. First, he *analyzes* (studies) the product to find out what operations are needed. Then he lists

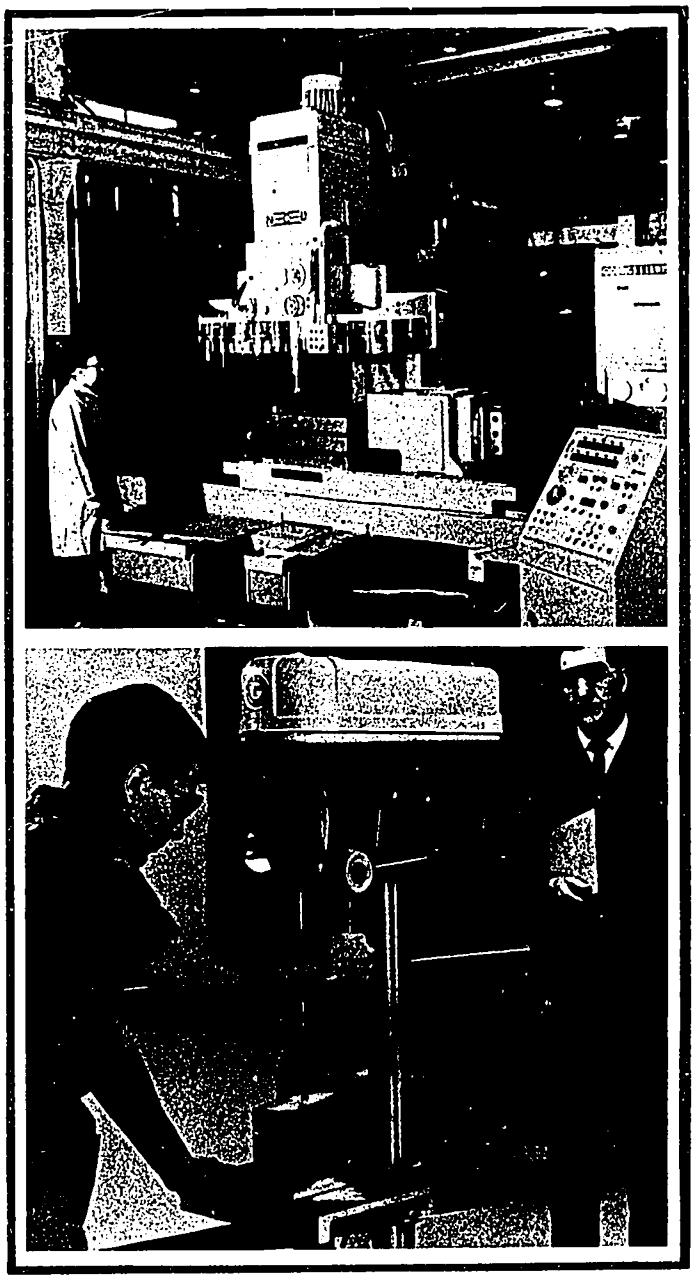


Fig. 20-5. These two machines may do the same kind of work. The production engineer must choose the one which will make the product most efficiently.

all possible ways to do each operation. These possible ways are then compared on the following six points:

1. *Availability*—Can the product be made on equipment owned by the company? If new equipment must be bought, new investment of money must be made. It may take many months to get new equipment because many large manufacturing machines are built only to special order.

2. *Capacity*—Will the method produce as many products as the company will need? Will the method have to be changed if there is increased or decreased demand for the product in the future?

3. *Quality*—Will the method produce acceptable quality? It may be wasteful to produce higher quality than needed.

4. *Personnel*—Must new operators be hired and trained if a new process is used? If new operators are needed, what will happen to the workers who are replaced?

5. *Materials Handling*—The problems of moving material are often greater than the problems of making a product. Material arriving at a plant must be unloaded. Then it must be moved to a storage area. From storage it must go to a production area, perhaps to several processing areas. The finished product must then go to a storage area. Later it must go to a shipping area and then out of the plant.

6. *Overall Economy*—Ideally, the methods and processes chosen will produce enough parts of good quality to satisfy the demand at the lowest possible cost. In order to compare processes, the engineer should find out the cost of several different methods and choose the least expensive.

Other Steps before Production

After the processes and methods have been chosen and before production can start, several steps remain. There must be space in the plant for new equipment. The plant engineer must be told of any new needs for *utilities* (water, gas, or electricity). Special tools and attachments must often be designed and made in order to do certain jobs. *Operation charts* and *job descriptions* are needed to explain the job to the foreman, to those who handle materials, and to those who use the equipment. *Schedules* (when materials should be in each place) and *routing sheets* (where the materials go next) must be made up. The right number of parts must be processed in each place at the right time.

Manufacturing Engineering Is a Continuing Task

Designing and engineering production does not end when production of a new product starts. There are many other times when engineering may be needed. When the engineer designs a new system, he does not always know how things will actually work. After production starts, he may find that parts of his design were wrong. Then changes will be needed. Production systems are designed to make a certain number of products in the most efficient way for that number. If customers want more products than can be made, changes in the production system may be needed.

The greatest changes in production happen when materials and processes improve. The product designer may find that a new or a different material will make a better product. Then the process engineer must change the processes and methods. Better ways of manufacturing may also be found. Most of these new methods do not change the main ways of shaping materials. Usually the improvements cut down on the amount of manual labor needed for production.

Fig. 20-6. Designing and engineering for production needs many workers. They include engineers, accountants, draftsmen, and office workers.

Summary

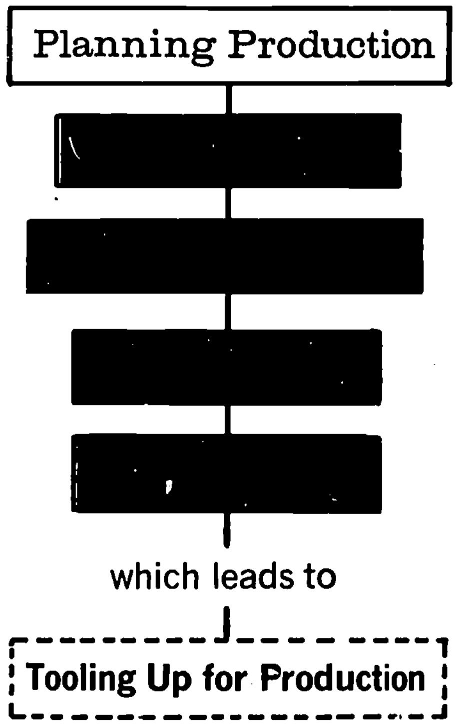
After a product has been designed and engineered, designing and engineering of production are important steps. During production, engineering must go on to make production more efficient. New processes and materials which need more production engineering may be found.

In the designing and engineering of production, the manufacturing engineer follows certain steps. First, he studies the product to find what production process will work. Second, keeping in mind the time, cost, quality, and quantity of each process, he chooses the most efficient production processes. Third, he checks over the methods of production being used. He is always looking for better ways. In the next reading, you will learn how processes are *analyzed* (studied) to find which one is the most efficient.

Organization for Manufacturing Engineering

Designing and engineering production is needed at many places and at many times in manufacturing. It starts with the product designer and may go on at *postprocessing* (service) facilities after the sale of a product. Small companies may have only a single manufacturing engineer. His job may also include time study and quality control.

Large companies with many plants often have a large, centrally located manufacturing engineering department. This is where most work, especially for new products, is done, Fig. 20-6. These companies also have smaller departments in each plant for solving day-to-day problems. Both small and large companies may hire *consulting* (outside) *engineers* to do part or all of their manufacturing engineering.

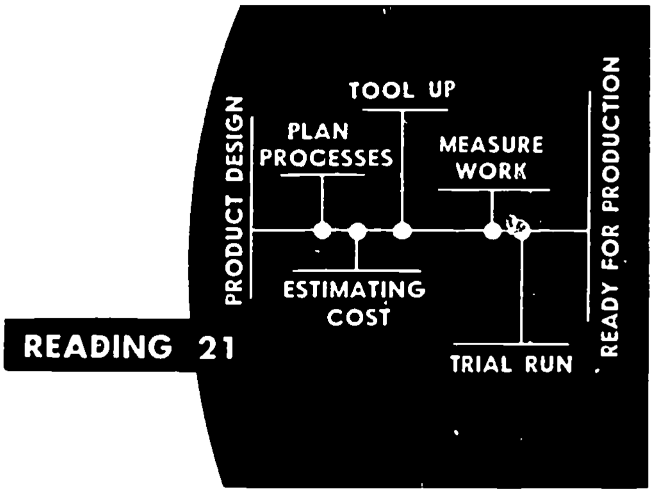


Terms to Know

trial and error method
industrial engineering
manufacturing engineering
producibility
analyze
availability
capacity
quality
personnel
materials handling
overall economy
install
productivity
process engineer
methods engineer
tool engineer
work measurement engineer
utilities
operation charts
job descriptions
schedules
routing sheets
postprocessing
consulting engineers

Think About It!

1. Manufacturing companies cannot plan their production of products by the *trial and error method.* Why not?
2. Why are many large manufacturing machines built only to special order?



Planning Processes

All the processes needed to manufacture a product must be designed and engineered in great detail. General plans for the processes were probably chosen before management approved the product design. Now the techniques of manufacturing and industrial engineering are used. The best combination of machines, processes, and people must be found.

Planning and Organizing

A manufacturing process like assembling can be done in many different ways. The best way to assemble refrigerators might be a very poor way to assemble typewriters. Manufacturing processes are studied in great detail by the manufacturing engineer. He is always looking for the safest, easiest, and most efficient ways to make his plant's products, Fig. 21-1.

A *process* is an organized set of operations. For example, a painting process includes operations like cleaning the surface, *masking* (covering surfaces not to be painted), putting on a base coat and several finish coats, drying the surface with radiant heaters, and unmasking. Each operation is done at a *work station* (a stopping place in the production line). A manufacturing engineer must know how to organize all these jobs so that the product will move smoothly along a production line. Part of planning the processes is organizing the work to be done on the production line, Fig. 21-2.

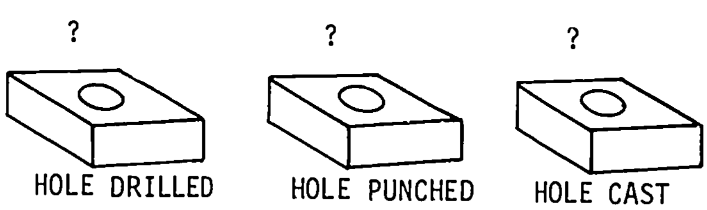


Fig. 21-1. The manufacturing engineer must determine which process would be most efficient for making a certain product.

The Manufacturing Engineer's Problems

An engineer designs processes for a new product or redesigns processes for a product already being made. He has the same kinds of problems in each job. There are always many kinds of machines or processes to choose from. He must also choose people with the right skills and training. The engineer must look at many things: cost, production rate, quality, safety, and the satisfaction of the workers.

The engineer must make the best choice of men, materials, machines, and processes. After much study, he may suggest buying a part (*component*) from another firm. He may suggest that another part be made in his plant. This decision to *make or buy* is important. Every part of a product probably could be bought somewhere else, or could very well be made in the company's plant. The decision to make or buy is based on cost. If the part can be bought for less than it can be made, management buys it! It is important to find out the exact cost of making a part and the exact cost of buying it.

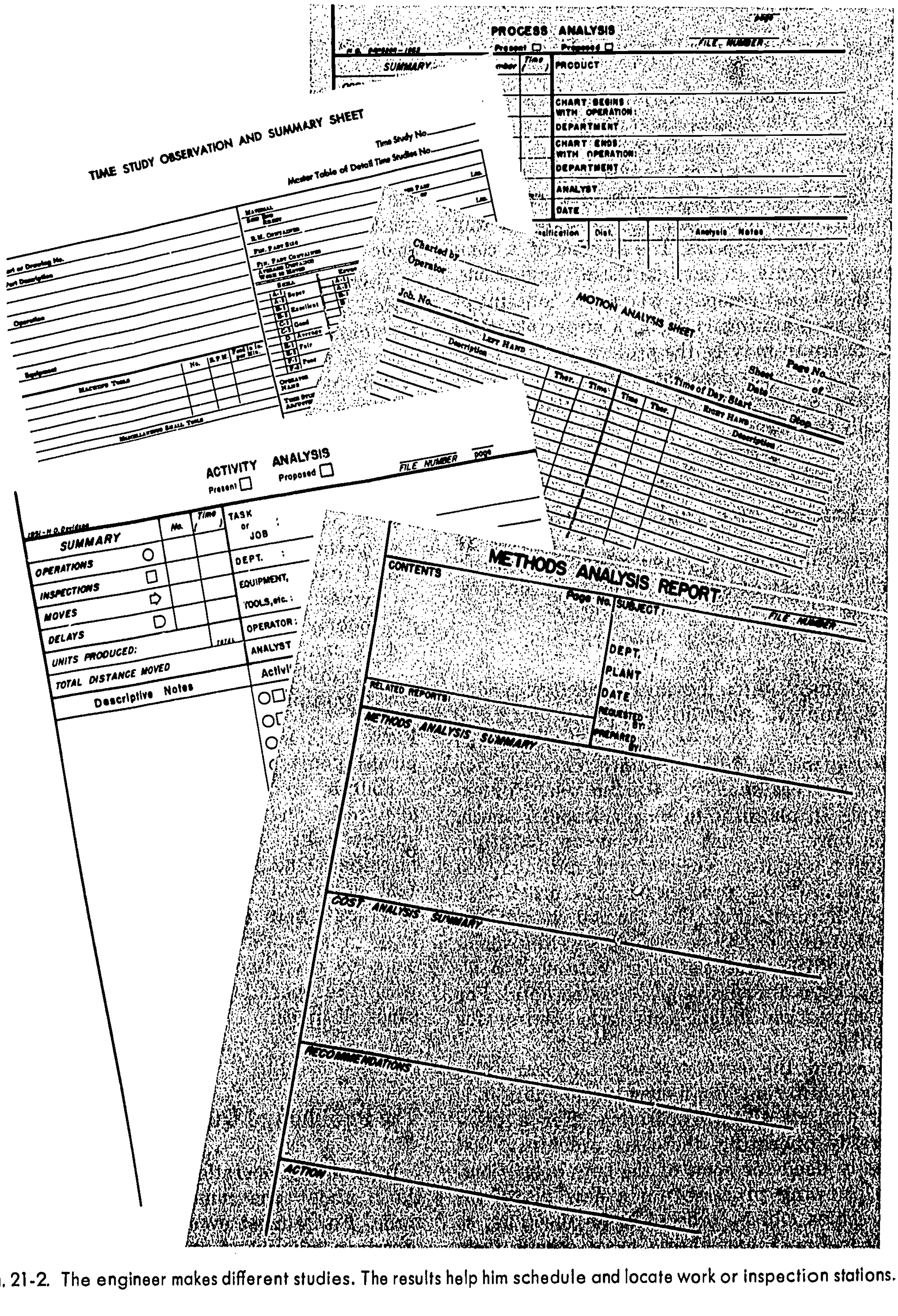


Fig. 21-2. The engineer makes different studies. The results help him schedule and locate work or inspection stations.

Responsibility for Planning Processes

In a large company, *process planning* is done by the engineering department. The chief of the manufacturing engineering group is in charge of the planning. He tries to get ideas from everyone in the plant. The production worker can often suggest a way to improve a process. The success of a company depends, in part, on these suggestions.

In a small company where the amount of process planning is small, a superintendent or foreman may be the process planner. But no matter who does the planning, the *techniques* (practices) of process planning are really the same.

Techniques of Planning Processes

The industrial or manufacturing engineer follows a set of steps in planning processes. These are:

1. Listing processes and operations,
2. Choosing work stations,
3. Analyzing (studying) work flow, and
4. Analyzing operation methods.

First, the *processes must be listed.* Then *alternative operations (other choices) for each process should be worked out.* For example, in planning to make a wooden bench, you may list such processes as painting, sawing, sanding, drilling, and nailing. You should put the processes in the order that they happen. For the planned bench the correct order may be sawing, sanding, drilling, nailing, and painting. You should always keep alternative processes in mind. For example, you might substitute gluing for nailing.

Second, the *work stations are chosen.* This job is different for a new plant than it is for a plant already operating. For a plant already operating, there are machines that can be used for some of the new operations. In planning processes for a new plant, the machines can be ordered to fit the plan, so the engineer can choose more freely from alternative operations. He tries to choose the right combination of men and machines. He wants to do the work at the least cost.

The engineer uses charts to show the jobs which several machines or people are doing at any one time. These charts help him find and get rid of times when machines or people are idle. This happens when workers must wait for the work they are supposed to do.

Third, *work flow (movement of materials from one work station to the next) is analyzed.* Work flow may be shown on a *flowchart.* This chart shows the order in which operations are done to make a product, Fig. 21-3. A flowchart helps in four ways:

1. It can find high cost areas of production.
2. It can schedule parts so that they are at the right place at the right time.
3. It can locate *inspection points* (places where products can be checked for poorly made parts).
4. It can place machines so that handling of materials or components is kept to a minimum.

Flowcharts also help in the design of new plant layouts.

Fourth, *specific operation methods are analyzed.* The process engineer carefully studies the movements of men and machines. One of his main jobs is to *reduce* (cut down on) costs. A *multiple activity chart* can help a worker keep both hands busy in an assembly operation. Shortening a job by even one second may reduce costs, when the operation must be repeated thousands of times.

The Problem of Quality

In choosing operations, the engineer must think about the number of parts to be made. For almost every operation there is a certain amount of preparation before the operation can start. Getting ready is called

Process Chart

NAME OF PART OR PRODUCT Cake Pan

(Chart begins at press area, ends in storage room)

ORDER NO. 1273	LOT SIZE 5,000	CHART 7 · DEPT. 72 · SHEET 1
ANALYST wew	DATE 7 July 71	BLDG. 5 · OF 1 SHEETS

TRAVEL IN FEET	TIME IN MIN.	SYMBOL	OPERATION	REMARKS
	.015	INS 1	Inspect for gage and smoothness	
	.017	1	Cut pan blank	
10	.10	1	Move blank to forming area	
	.015	2	Form into pan	
7	.95	2	Move to grinding and deburring area	
	.215	3	Grind and deburr	
	.015	INS 2	Inspect for defects	
25	.23	3	Move to cleaning area	
	.01	4	Clean pan	
	.02	INS 3	Inspect for cleanliness	
10	.50	4	Move to finishing area	
	.01	5	Coat with primer	
	.10	1	Wait for primer to dry	
	.02	6	Coat with Teflon finish	
	.10	2	Wait for finish to dry	
	.02	INS 4	Final inspection	
25	.40	5	Move to packaging department	
	.01	7	Pack	
		▽		

Fig. 21-3. Process charts show the operations done to different parts of a product. They show where the parts or product must be handled, inspected, stored, and assembled.

setup, Fig. 21-4. After setup, there is a fixed time and cost of production for each part made (*unit of production*). The cost of setup time will influence the per-unit cost of the product. Thus the shorter the setup time and setup cost, the lower the per-unit cost of the product. The cost of the product is also influenced by the number of product items produced. Short production time increases the cost per item. Long production time lowers the cost.

For example, suppose that a label must be pasted onto each bottle on a production line. A workman might do this job by hand. Setup would be handing him a pastepot. A machine to do the same job might be very expensive, especially if it had to be *custom designed* (designed for this special purpose). But its production time and cost for each unit (each bottle labeled) would be very low. For a few hundred bottles, a workman with a pastepot would be the least expensive choice. For millions of bottles, a machine would be the least expensive. For thousands of bottles, the engineer would need to look at many cost and production figures before he made his choice, Fig. 21-5.

Some companies specialize in making certain products. Other plants specialize in *performing* (doing) certain operations. But *specialization* (working in one area) goes beyond this. A company may specialize in making its products in *quantities* (amounts) that it can turn out efficiently with its setup. A plant may specialize in performing its operations on only a certain number of parts.

Most manufacturing plants have a toolroom. It has easily changed, *multi-purpose machines* (machines with many uses). These machines have short setup times, but long production times. Toolrooms specialize in making only one or a very few of each item: special tools, fixtures, repair parts for machines, and developmental models. Production areas usually have machines with very large setup costs but very short production times.

The manufacturing engineer must choose from several different methods. Figure 21-6 shows the cost of drilling holes in the end of an electric motor frame. For this operation, *setup cost* is the cost of getting ready before any parts are drilled. The *unit production cost* is the cost of drilling each part after the setup. The costs in the chart are

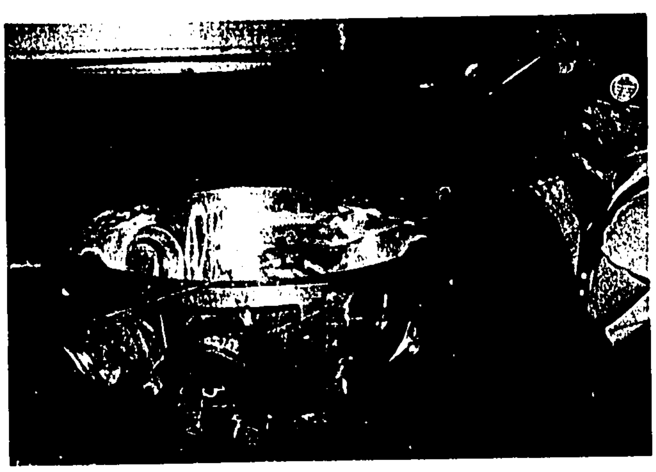


Fig. 21-4. Equipment with a short setup time is needed when only a few parts are needed. This kind of equipment is costly for mass production.

Fig. 21-5. When many parts are needed, special equipment is often used. It takes longer to get ready for production, but the cost of each product is less after production starts.

average costs for drilling one part. They differ, depending on how many parts are made by each method. This is the least price a company would have to charge for this operation to pay for the setup and production. The cheapest price for each number of parts is shown in the boxes of Fig. 21-6.

The engineer must make a wise choice among these methods. He must know how many frames, for example, are to be produced per day or per month. A large investment of money is needed for setup if large numbers of frames are to be drilled at a low average cost.

Similar examples could be found for producing chemicals, weaving cloth, printing books, generating electricity, and for most other production jobs.

Planning Is a Continuing Task

The planning of processes and methods does not stop when a new product goes into production. Changes in design may mean different processes and methods. An increase in customer demand for a product may mean different methods. New processes may be developed that were not known when the product was designed. If *competitors* (other companies in the same kind of business) find better ways to produce, they may be able to sell their product at a lower price. The manufacturing engineer must keep working to find a better way.

Summary

Process planning is part of production planning. Processes and operations are designed and engineered to find the safest, easiest, and most efficient combination of people, processes, and operation methods, Fig. 21-7. The main purpose of this planning is to reduce costs. Process planning is done by engineers, but accountants, foremen, and production workers all help. The most efficient process often depends on the product and the operations to be done. It also depends on the quantity to be made. In the next reading you will find out how *automation* is used to improve the efficiency of many processes.

Jig Boring Machine	$6.00	$5.00	$11.00	5.60	5.06	5.00	5.00
Tape Controlled Drill	$10.00	$2.00	$12.00	3.00	2.10	2.01	2.00
Jig and Drill Press	$200.00	$1.00	$201.00	21.00	3.00	1.20	1.02
Multiple Drill	$1000.00	$0.50	$1000.50	100.50	10.50	1.50	.60

Fig. 21-6. This chart shows how the setup cost affects the average cost for producing a single unit. Increasing the setup cost lowers the average cost. In each average cost column, the lowest cost is in color.

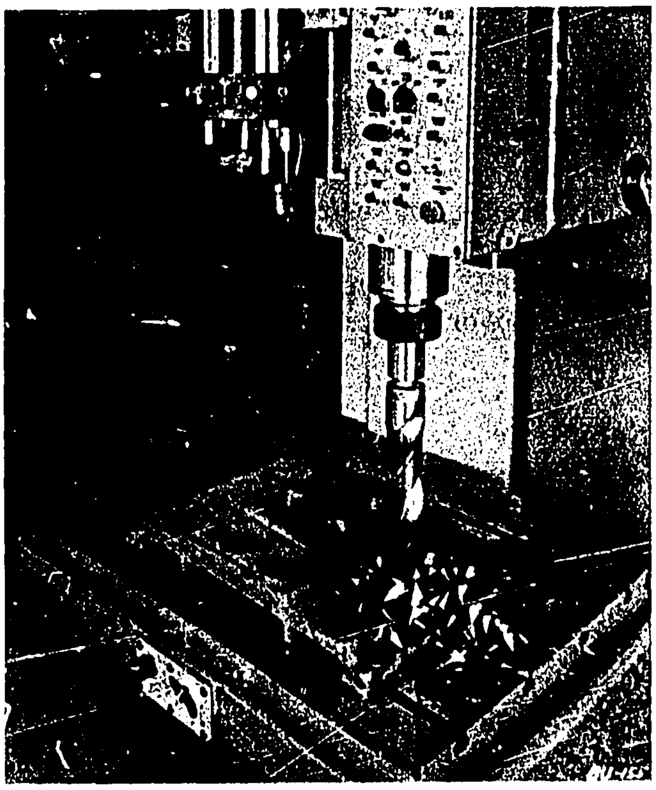


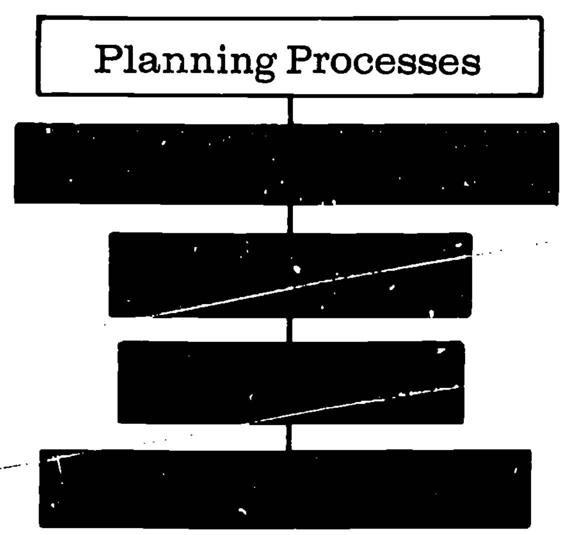
Fig. 21-7. There are many different ways for drilling the holes in this casting. The best method depends on how many are to be made.

Terms to Know

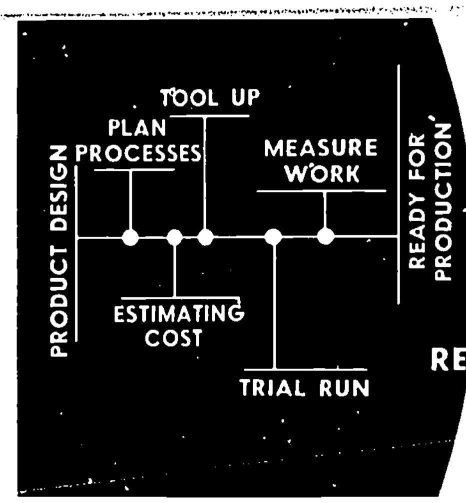
- process
- masking
- work station
- component
- make or buy
- process planning
- techniques
- alternative operations
- work flow
- analyzed
- flowchart
- inspection points
- reduce
- multiple activity chart
- setup
- unit of production
- custom designed
- performing
- specialization
- quantities
- multipurpose machines
- setup cost
- unit production cost
- competitors
- automation

Think About It!

1. How can a worker on a production line help his company find new ways of lowering production costs?
2. What happens when new processes are discovered that were not known when the product a company is making was first designed?



Automating Processes



READING 22

Competition in industry has made companies look for better ways of producing. *Methods study* is used to find the best way for people to work. It has also been used to develop better processes and equipment. Usually, methods studies are used to reduce or do away with the amount of manual labor needed to do production work. As early as 1611, a manufacturer in England built a lacemaking machine in which the lace pattern was controlled by a punched card. By 1914, electric light bulbs were made in large numbers on automatic equipment that needed few or no operators. Today, such developments are called *automation.*

Automation Defined

The word *automation* is hard to define, but in manufacturing it always means using mechanical devices in place of manual labor. If a worker is still needed to control a machine or process, the development is called *mechanization.* When the *controlling* (thinking) part of man's work is *programmed* (by a set of instructions) into a machine, then automation is being used.

Reasons for Automation

The main reasons for using automation are to:

1. Increase production *capacity,*
2. Reduce waste,
3. Improve working conditions,
4. Improve *distribution,* and
5. Reduce cost.

Most automation has been used in industries that produce in large quantities and have many *repetitive* operations (done over and over). These industries can usually afford the large investment of money in machinery needed before production can start.

Automation often means less waste. There are fewer scrap parts because there are fewer human errors. There may be less wasted time because automated machines are often faster than hand-operated machines. Even if they are not faster, they do not need time to rest as people do. An automated machine also does not have to wait for a worker to load and unload workpieces, Fig. 22-1.

Even though no money may be saved, management often tries to do away with

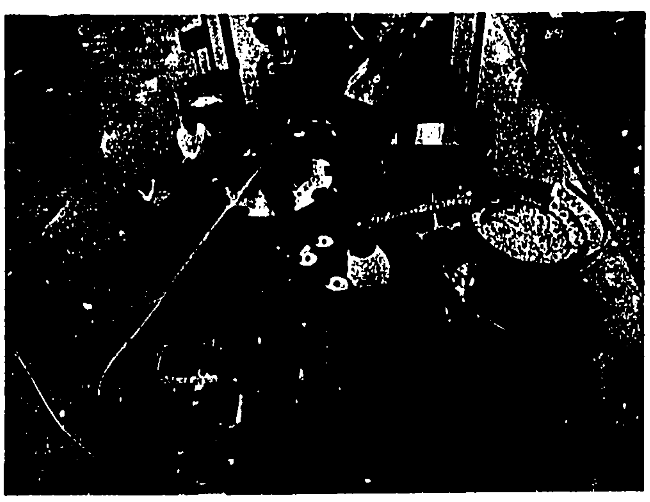


Fig. 22-1. This slide tray assembly line is one of many integrated production units now located at the Elmgrove plant, newest part of the Kodak Apparatus Division. It combines a 200-ton progressive die punch press, industrial cleaners, an assembly turntable, and an automatic packing machine.

dull, repetitive jobs. Jobs like loading and unloading, assembling small parts, and inspecting finished work become boring and tiring to most people.

Automation has greatly reduced the amount of manual labor needed for production. This reduction in the use of manual labor usually lowers the cost of production by raising the amount of production. Automation also means that the workers must be better trained and more highly skilled, Fig. 22-2. Automation has made more jobs for supervisors, engineers, technicians, and maintenance workers.

Fig. 22-2. Automation means that many more jobs need skilled workers. Many plants must train workers over again when automated equipment is first braught in.

Automation can make a machine or process more useful. Many different products can be made with one automated machine. *Tape-controlled* (automated) machine tools can produce small quantities more efficiently than standard machines. But automation can also create new problems. An automated production or assembly line for automobile engines uses much equipment that is designed for only one engine size, Fig. 22-3. Many engines of the same kind must be made. Otherwise, there is no reason for the large investments of money for such equipment.

Personnel in Automation

The designing and engineering of automated equipment is highly specialized. Usually it is done by engineers trained in one field. They may be chemical engineers, ceramic engineers, mechanical engineers, or others. Engineers with different kinds of training often work in groups on the development of automated equipment, Fig. 22-4. The use of automated equipment in production is most often planned by the manufacturing engineer.

Management personnel work with manufacturing engineers to find out how much

Fig. 22-3. Many production lines are designed to be used for only a single product. The manufacturing cost is very low for this product, but design changes are costly.

Fig. 22-4. The design of automated equipment often needs the services of many people. These engineers have different training and backgrounds. They can all help with the design.

automated equipment to plan for. Many human problems came about when mechanization and automation were first used. For example, the jobs of many people were done away with by the use of mechanical coal mining, cleaning, grading, and handling equipment. These people lived in an area where they could not get any other work, so they had to move away or stay out of work.

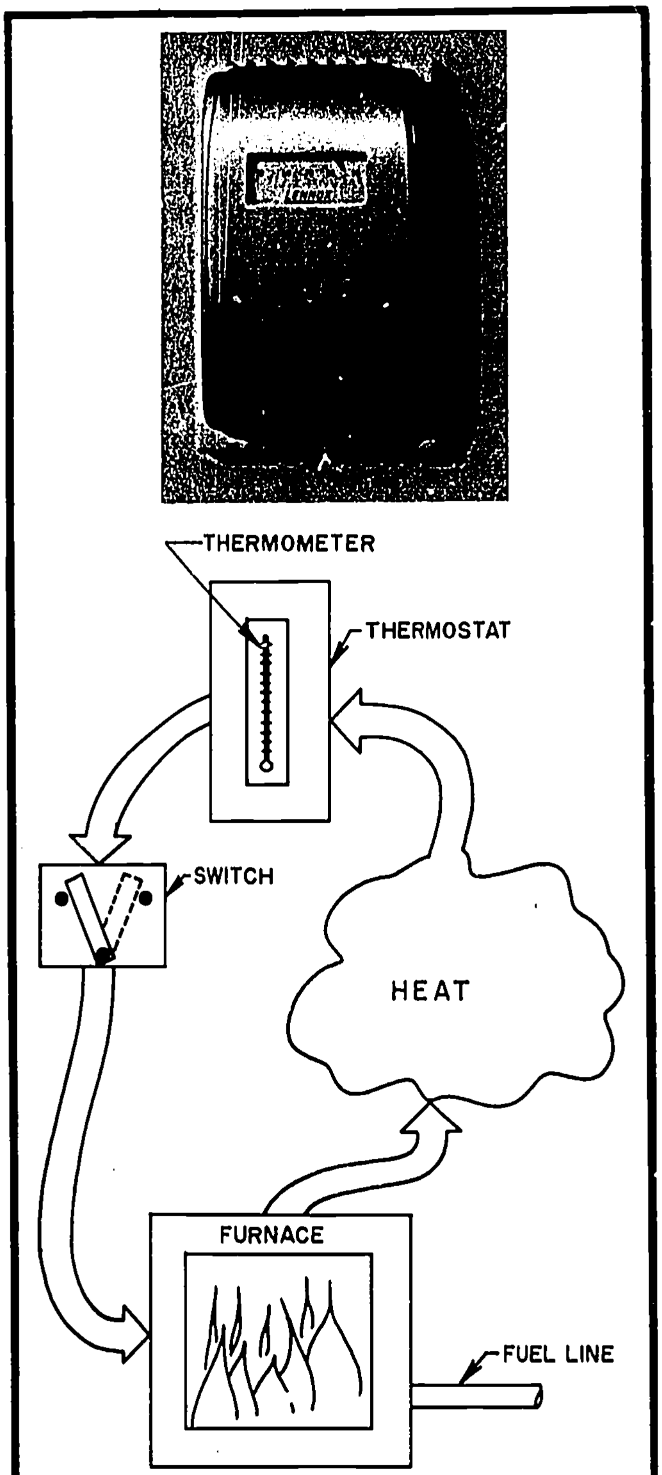


Fig. 22-5. A home heating system uses the principle of feedback. The wall thermostat measures the temperature and sends signals to the furnace to control its output.

Principles of Automation and Mechanization

Automation has had two main fields of use in manufacturing. These are *machine control* and *automatic handling of materials.* Automation has always used at least one of four principles. They are:

1. *Feedback,*
2. *Mechanical handling,*
3. *Programmed control,* and
4. *Data processing.*

In *feedback,* the *output* of a process or machine is measured. The measurement of this output is used to *regulate* (control) the process or machine. Home heating systems use the principle of feedback, Fig. 22-5. The thermostat measures the temperature in the home and feeds back signals to the furnace. To keep the temperature in the home always the same, the furnace produces more heat if needed.

The word *automation* was first used by an engineer from an auto company. He described it as the technique of automatic *mechanical handling* of parts between work stations. He meant the use of conveyors and other mechanical transfer devices. Such devices are not new, and they are widely used today. This kind of automation is called *mechanization,* or Detroit automation. Manufacturing plants that process chemicals, paper, steel, and petroleum use automation to handle all materials from raw materials to finished products.

You may have seen or used a coin-operated hot-drink dispensing machine. It runs on the principle of *programmed control.* Depending on the button that the user pushes, the machine has been programmed

to produce hot chocolate, black coffee, coffee with cream, coffee with sugar, or coffee with cream and sugar, Fig. 22-6.

One of the fastest growing kinds of programmed control is called *numerical control.* It is most often used for machine tools that cut metal. The motions of the machine, even those for choosing the proper tool, are controlled by a series of holes in paper tape. The holes are punched in a code that the machine *converts* (changes) into action, Fig. 22-7. You may have seen an electric typewriter or teletype machine that was also controlled by paper tape.

Automation often depends on *data processing.* Information is given to *computers* by engineers and other workers to control machines or to handle material. Computers, using data from cards or tape, often are used in the automated system, Fig. 22-8. They process feedback information that makes automated control possible.

Fig. 22-6. This machine has been programmed to dispense different kinds of milk. Production machines are often programmed in a similar manner to perform different operations.

Applications of Automation

The use of automation has increased as times have changed. Rising wages have caused engineers and management to reduce the amount of labor needed in production. Increased amounts of capital have been needed for the large investments in automated equipment. Numerically controlled machines have made possible the production of some parts that could not be made a few years ago.

Automation was first widely used in the metal processing industries, mainly for assembling and handling materials. Automation has gradually spread to all the

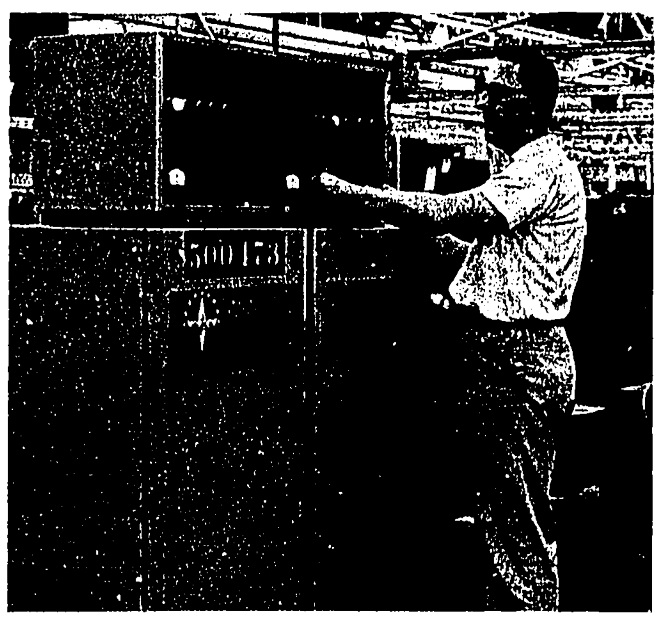


Fig. 22-7. The program for operating this machine is changed into a series of holes punched in paper tape. The holes are read as numbers by the machine. The numbers control the motions and actions of the machine. Different programs may be written for different parts of a product.

manufacturing industries. Steel mills use feedback from a measuring device to control the thickness of rolled sheet steel. For many years, oil refineries have used feedback controls and computers to get the best combination of oils and gasolines. In many bakeries unloading, weighing, mixing, baking, sorting, and packaging are done without manual labor.

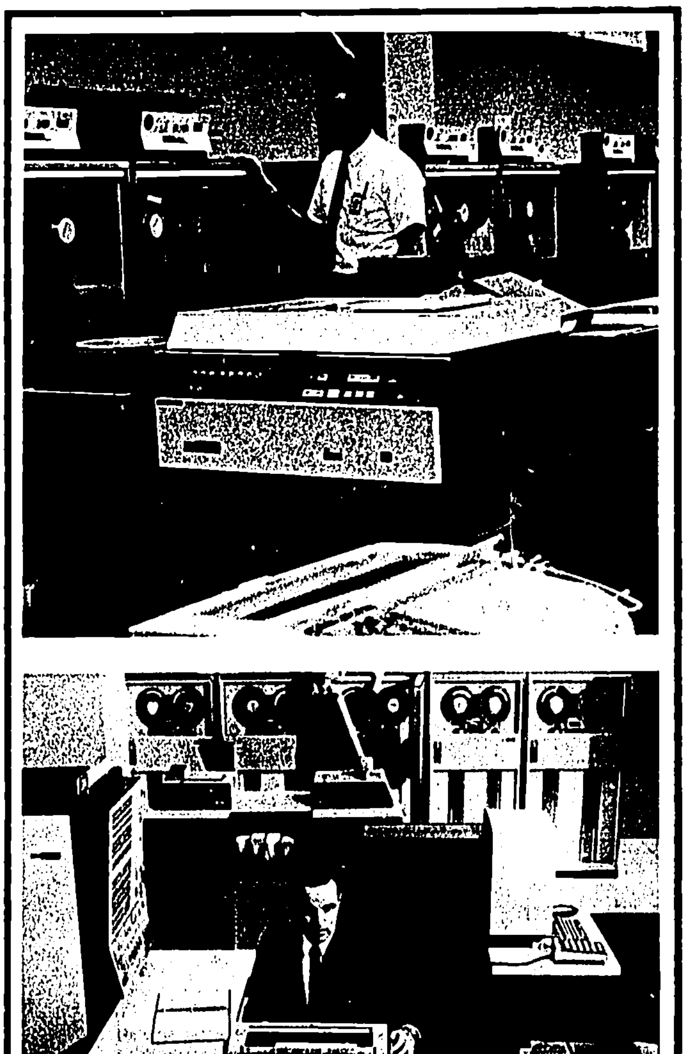


Fig. 22-8. Computers are programmed to store data and perform mathematical operations on the data. They have many uses in industry.

The most unusual uses of automation are in *materials handling*, Fig. 22-9. The handling of materials starts at the receiving and unpacking area (the receiving department). From the receiving department, the raw materials are moved into and through the processing departments. From the processing departments, the product goes to final inspection and packaging. The next step is to move the packaged product to a shipping vehicle, storing area, or a warehouse.

One survey showed that 25 percent of the cost of manufacturing came from handling materials. Other surveys ran as high as 60 percent. The handling of materials adds no value to the product, so whenever a new factory is being planned or a present one is being remodeled, the materials handling system should be studied carefully.

In a completely automated plant, it would only be necessary to feed raw materials and programmed instructions into a process. The finished product would be made without human labor. Of course, human labor would be needed to build and maintain the equip-

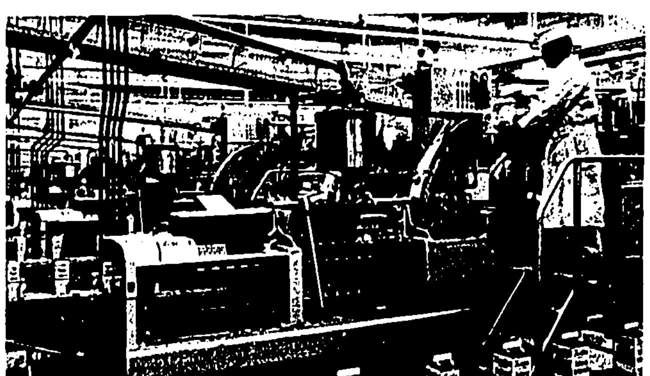


Fig. 22-9. Large dairy plants are among the most completely automated of industries. Large quantities of dairy products are produced with little or no manual labor and in a short period of time.

Fig. 22-10. Progress in chemical production is shown by this control panel. The control panel shows what is going on in every part of the plant.

ment, Fig. 22-10. This degree of automation can already be found in power generation plants and oil refineries.

Summary

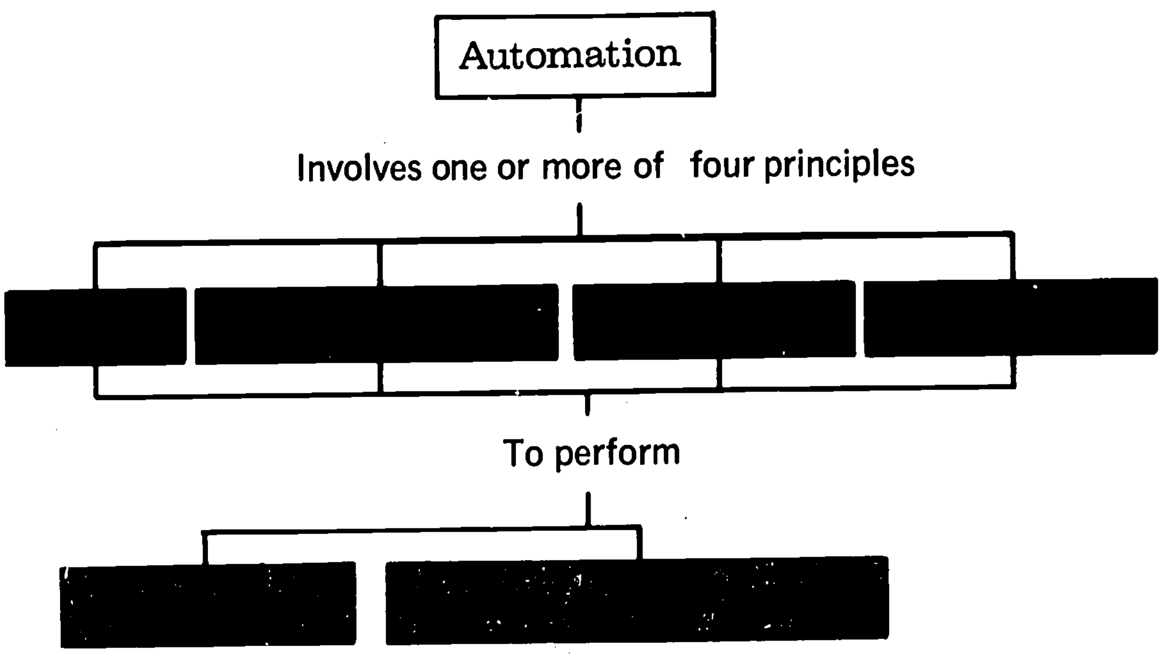
Man is always seeking ways to reduce the amount of human labor needed for production. Automation reduces labor on certain jobs by using feedback, mechanical handling, program control, and data processing. Many of these systems are not new, but their use is increasing in industry. Human labor may be reduced on certain production jobs, but automation has increased employment in related fields.

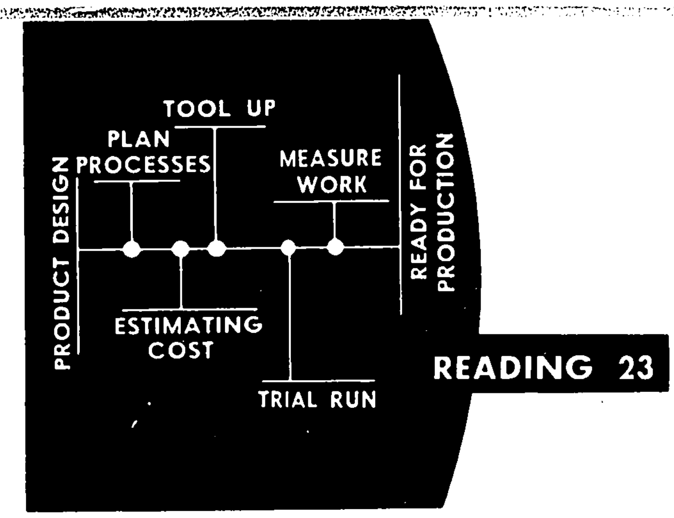
Terms to Know

methods study	automatic handling
automation	feedback
mechanization	mechanical handling
controlling	programmed control
programmed	data processing
capacity	output
distribution	regulate
repetitive	numerical control
tape-controlled	converts
machine control	computers
	materials handling

Think About It!

1. What help can be given to people who must move or must remain out of work when their jobs can be done by automated equipment?
2. Has *automation* affected your life? Explain.





Measuring Work

Planning processes, including automation, can be done well only if management has the right information. The amount of time needed for an operation is often the most important piece of information. This reading is about the techniques used to find out the amount of time needed to do a job.

Planning Your Time

Let us take a look at a routine of yours. If you must be in school at 8:30 a.m., you may get up at 7:30 a.m. You get up at 7:30 a.m. because you estimate that it usually takes you about:

10 minutes	To wash and brush teeth
10 minutes	To get dressed
15 minutes	To eat breakfast
15 minutes	To walk to school
10 minutes	To talk to your friends and get to your seat
60 minutes	

Thus, you have measured the time for your activities.

In manufacturing production, we do this same thing to determine the amount of work that can be accomplished during a period of time. The many production methods needed to make a product have already been studied. This *analysis* (study) shows that most of them depend upon some *time factor*.

Work Measurement

The total time to perform many manufacturing production tasks may be divided into two parts. First, there is the *machine time.* The worker often has little or no control over machine time. Second, there is the *man time,* often called the *handling time*. See Figs. 23-1 and 23-2. Man time includes loading, unloading, assembling, adjusting, inspecting, moving, and using any hand tools. The time it

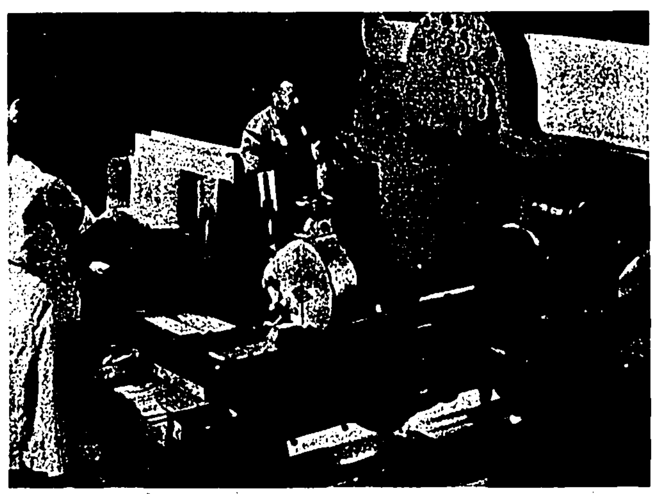


Fig. 23-1. The total time for production includes handling time and machine time. One of these workers is waiting for the machine, but he must still be paid for this time.

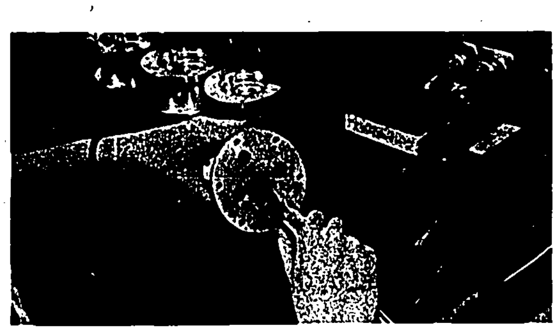


Fig. 23-2. Work measurement is the study and measurement of man time. Man time includes handling, inspecting, using hand and machine tools, and many other actions of the worker.

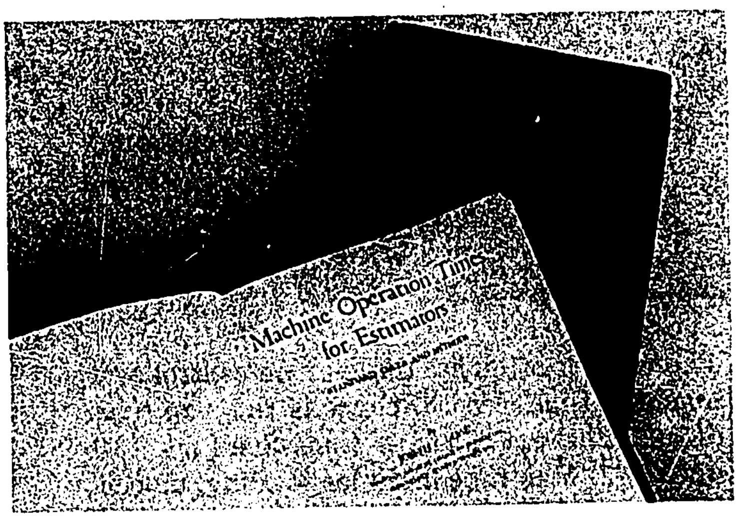


Fig. 23-3. By work measurement, an industry finds the average time needed to do each operation.

takes to do these jobs depends on how skilled the worker is and how fast he works.

The various *methods* or ways of performing a job and the use of equipment are also important in measuring work. For example, in estimating the time it takes you to get to school, it is important to you to determine the route you take in walking to school. If you had to cross three intersections controlled by traffic lights while walking to school, the amount of time that these lights might delay you would be important to your calculation of walking time. Thus, your walking time is *man time;* the time it takes traffic signals to change is *machine time,* and the route you take would be the *method.* You could continue the analysis and include equipment, by raising the question of walking or riding a bike.

Work measurement, then, is the study of *man time, machine time,* and the various *methods of performing a task.*

About 70 years ago an engineer named Frederick W. Taylor made the first serious attempt at measuring work. He taught a man named Schmidt to shovel 47 tons instead of 12½ tons of pig iron a day. Every detail of the man's job was specified: the size of the shovel, the bite into the pile, the weight of the scoop, the distance to walk, the arc of the swing, and the rest periods that Schmidt should take. By varying each of these elements, Taylor got the *optimum* (most) amount of work out of Schmidt.

Importance of Work Measurement

In planning production, knowledge of man time is needed for several reasons. The correct choice among different ways of doing a job can only be made if the times are known. The time needed for each operation is used to decide how many pieces can be made or how many machines and workers will be needed, Fig. 23-3. Suppose that one man at a machine takes one minute to make a piece. Thus, he could produce 480 pieces in eight hours. Suppose that we needed 7,200 pieces a week, or 1,440 pieces a day. Assume that we work eight hours a day, five days a week, without any *operator relief* (rest periods for the worker and *down time* (time during which a machine is shut down). We then would need to buy three machines and hire three men.

Time means *cost.* Only by knowing the production times can accurate *cost estimates* (predictions of how much production time will cost) be made. The least expensive method can be found from these estimates.

In many industries one of the uses of work measurement is to figure the worker's pay. This is sometimes called an *incentive system.* The idea is that if a worker is paid according to the amount he produces in a period of time, he will produce more because of his *incentive* (desire) to make more money. Because work measurement affects his wages and method of work, the worker is concerned that the measurement be fair. The determination of what is fair is often a controversy between *unions* (workers' organizations) and management.

Work Measurement Personnel

When the field of work known as *industrial engineering* first developed, its main job was work measurement. Work measurement is

still the job of the industrial engineering department in most companies. However, the actual measurement of work may be done by other persons. They may be specially trained technicians called *time study analysts, time and motion study men,* or *work measurement analysts.* Work measurement may also be done by foremen, office managers, or engineers. Because of the controversy mentioned earlier, unions sometimes have full-time *time study representatives* who also measure work.

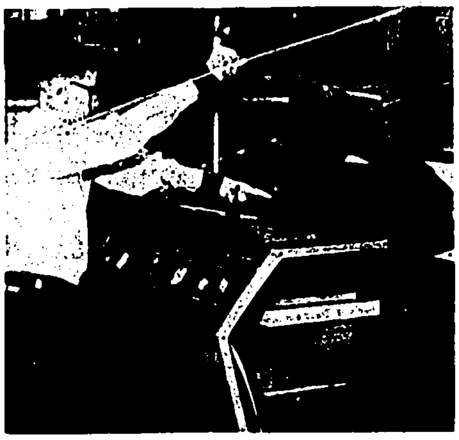


Fig. 23-4. Motion pictures of operations like this may be studied in slow motion to find wasted motions. They may also be used to get standard data for basic motion-time systems.

Equipment and Methods of Work Measurement

Most work measurement is done with a stopwatch. Motion picture cameras are also used to make detailed studies of assembling operations done over and over. The camera takes pictures of the worker who is being timed, Fig. 23-4. A clock with a large second hand is included in the picture. Cameras may also be used in other studies. Recorders may be attached to machines to record the time each part is finished.

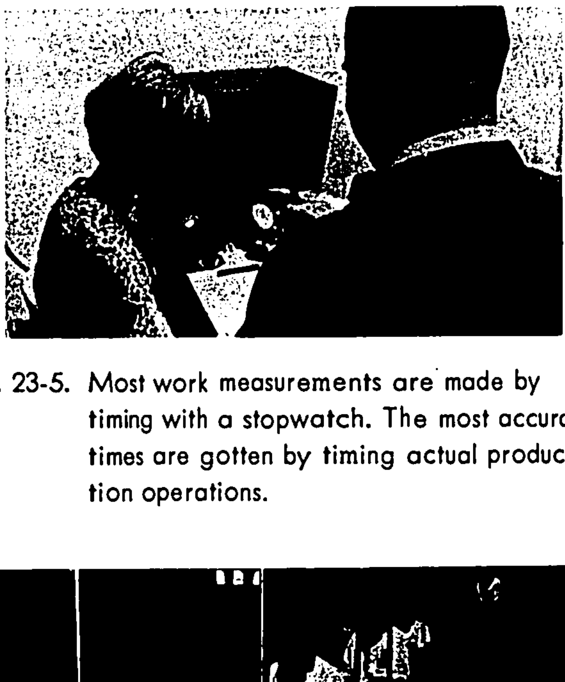


Fig. 23-5. Most work measurements are made by timing with a stopwatch. The most accurate times are gotten by timing actual production operations.

The most common method of work measurement is to observe the operation and time it with a stopwatch, Fig. 23-5. If you have watched a race, you may have seen an official time the race with a stopwatch. He has timed something in the same way a time study analyst would. A stopwatch is generally attached to a time study board. A time study board is designed to fit the contours of the time study analyst's body. The watch is placed in the upper right-hand corner of the board for a right-handed person. To the left of the watch is a spring clip used to hold the time study forms. All the details of the time study are written on these forms.

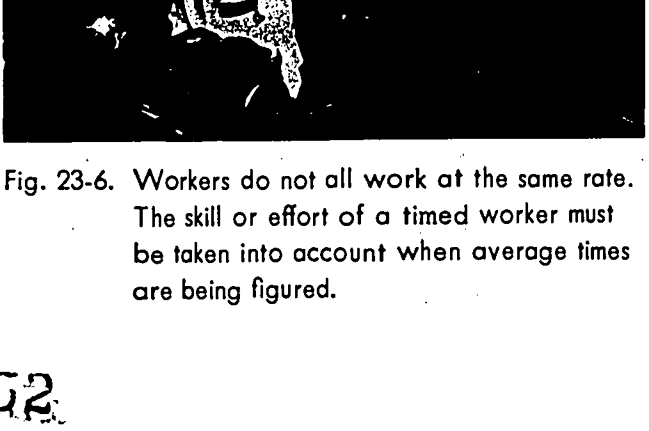


Fig. 23-6. Workers do not all work at the same rate. The skill or effort of a timed worker must be taken into account when average times are being figured.

The timer observes the task to be performed and breaks the job into *elements* (parts of the total task). A recording of time for each element is made. After a number of recordings of each element are made, they are added and averaged, Fig. 23-6. There are other factors that need to be considered, such

as normal interruptions that occur while working (*job allowances*) and the pace of the worker (*performance rating*). The timer must make a judgment as to how nearly normal the worker is performing. He may decide that a worker was working 20 percent more than normal when he was timed. Suppose the man had worked for five minutes on some job. The timer would multiply the five minutes by 120 percent to get six minutes. Six minutes would be the time an average worker should take for this job.

A process called *work sampling* is often used as part of work measurement. Suppose the engineer wants to find out if too much time is being lost while an operator of a machine waits for material. He could make 200 *random* (unplanned) observations of this worker. Suppose that during 20 of these observations the worker was *waiting for material.* The engineer would then figure that *about 10 percent of the time the worker was idle* due to lack of material. This information would be used to set the worker's pay, to make cost estimates, and to decide if better material handling equipment is needed.

It was found by Frank Gilbreth, an early industrial engineer, that basic movements were similar in all work. Each of these small movements, such as reach, grasp, search, and transport, was called a *therblig.* (How did he invent that word?) By calculating times for each therblig and adding them together, he could compute the total time for the task. There are in the manufacturing industry many systems like this that used standard times for basic movements that are common to production. The systems are commonly referred to as *predetermined time systems* or *standard data.*

A Continuing Activity

Work measurement goes on after production starts. New data are needed to decide on improvements in methods. Work measurement may also be used to change a worker's pay or his job. Many disputes between labor unions and management take place over work measurement. They disagree over how work should be measured and what is fair or normal. See Fig. 23-7.

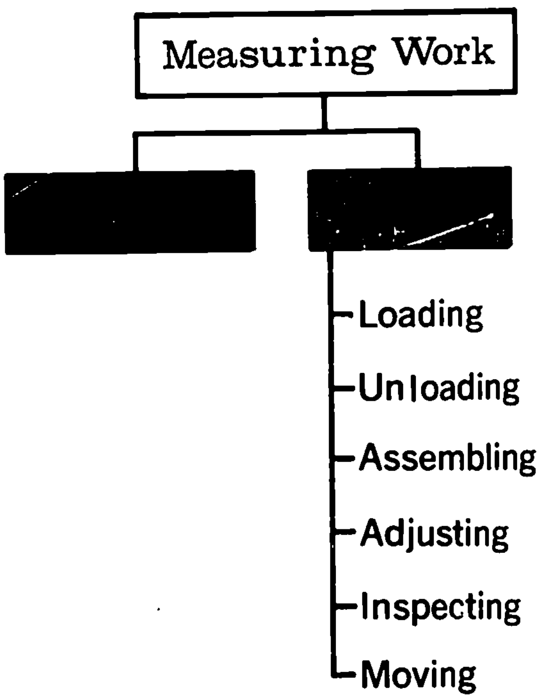
Fig. 23-7. Work measurement is the source of many disputes between management and labor unions. Labor and management often have different feelings about what average work means.

Summary

Work measurement is finding the average time and best method that it takes for any operation. It is usually done by specialists in the industrial engineering department. In the next reading, you will study how the times and methods found in work measurement are used in estimating costs.

Terms to Know

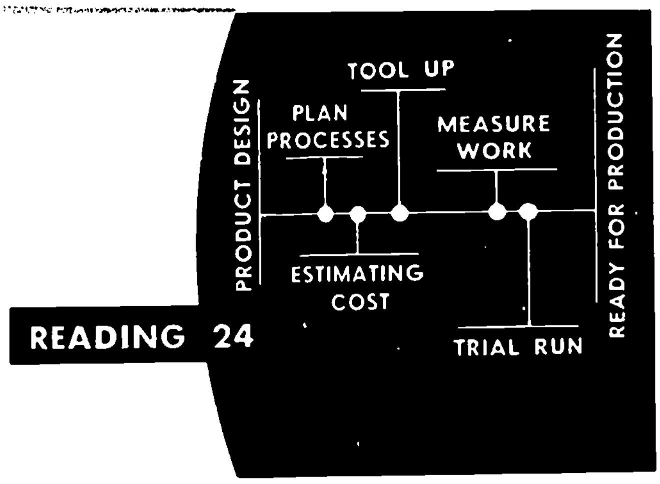
analysis
time factor
machine time
man time
handling time
methods
optimum
operator relief
down time
cost estimates
incentive systems
incentive
unions
industrial engineering
time study analysts
time and motion study men
work measurement analysts
time study representatives
stopwatch
elements
job allowances
performance rating
work sampling
random
therblig
predetermined time systems
standard data



Think About It!

1. How much time, on the average, does it take for your family to do the dishes at night? Time the process every evening for a week, from the moment the table is cleared until the last dish is put away.

2. Why do labor unions and management disagree over *work measurement* processes? How are these disagreements settled?



Estimating Cost

In the last reading you learned how work measurement analysts measure the time it takes to do a job. A worker's time is a part of the total cost of production. In this reading you will learn how management *estimates* (predicts) the total cost of production. The total cost includes the costs of labor, material, and other factors.

Cost estimates are the best *forecast* (prediction) of what the cost will be for something that has not yet been done. Cost estimates are *approximations* (more or less exact).

Importance of Cost Estimating

Cost estimates are used in two ways. When the engineer plans production, he must have cost estimates of the different possible processes. He can then choose the lowest cost process for production. He must also make cost estimates to show that some change in production processes would be *economical* (save money).

Cost estimates are also necessary to figure the *selling price* of goods and services. Your parents may have taken their car to several service shops to have cost estimates made for repairing a fender. The *cost estimator* at each repair shop has an important job. If his estimate is too high, some other shop will get the work and make the profit. If his estimate is too low, his shop may get the job but there may be no profit and there may even be a loss, Fig. 24-1. The shops with good estimators are the ones most likely to grow. The others either get too little business or lose money. Estimators are very important to shops that do contract work for others, instead of making products that they sell themselves.

Even after products are made, it is not always easy for management to know what the selling price should be, Fig. 24-2. Cost finding sets the selling price for complicated parts and assemblies after they are made.

Fig. 24-1. Many companies get jobs only by bidding against other companies. If the estimator is wrong, the company either does not get the job, or does not make a fair profit.

The Cost Estimator

Cost estimating uses the work of the product designer, manufacturing engineer, accountants, supervisors, inspectors, purchasing department, and production workers. The cost estimator himself must collect and *evaluate* (judge) information from all these people. He must understand the work of all these people to make a precise estimate. He often has an engineering back-

ground. An understanding of accounting, methods study, and time study are very important to him.

Making the Estimate

Cost estimates are all based on the fact that no job is completely new, Fig. 24-3. Any job can be broken down into parts that have been done in the past. The average times for these parts can be added together to get an estimate of the time for the total job. The *time* can be changed to *cost.*

In the construction industry, the contractor estimates costs on the basis of units of production. In estimating the cost of a new house, for example, the unit of production is one square foot of floor space. The estimator knows from past experience that, for similar kinds of construction, the cost per square foot is about the same. He may use a different cost for wooden frame, brick, one-story, or two-story construction. He may also add to the estimate such extra items as fireplaces, garages, or extra bathrooms.

This way of finding cost is also used in estimating the cost of metal castings. The unit of production is one pound. A different cost per unit of production is used for different metals.

A similar system is used in the printing industries. The unit of production is one page. A fixed setup charge, however, is added to the estimate. Both the setup charge and the cost per page are different for different printing processes.

Most estimates of the cost of manufactured goods are more complicated. They are made by dividing the total manufacturing cost into several parts. Then the cost of each part is estimated separately.

Material costs are usually the easiest to *calculate* (figure). Many materials are

Fig. 24-2. Even after products have been made, manufacturers often figure the selling price on the basis of estimates. It is hard to keep enough records to be sure of the manufacturing cost of every part.

Fig. 24-3. Estimated times for operations are based on standard data. These data have been collected in the past for similar types of operations.

bought by the pound, Fig. 24-4. The cost estimator figures the weight of the product. To this he adds a certain weight for waste and scrap. The weight has been figured from past production operations.

Labor costs are another cost estimate. There is only one worker whose time can easily be connected with a product. He is the actual production worker who works directly on the product. The time he puts in is called *direct labor*. Using *standard data* (data collected from similar jobs in the past), the estimator figures an average time for a production operation. Extra time must always be added to the figure obtained from the standard data. Cost estimators know that people cannot work well for long periods of time without some rest. Time is added for personal needs, fatigue, and other factors, Fig. 24-5. For some jobs, such as working at an open-hearth furnace, the fatigue time may be as high as 50% of the total working time.

A company also has other workers whose pay must come from the sale of *goods* or *services*. These people include engineers, office workers, janitors, salesmen, foremen, and all other workers of a company. It would be hard to estimate how much of each of these workers' time should be charged

Fig. 24-5. Estimates must include some rest time for the worker. For some hard jobs, the fatigue time may be as high as 50 percent.

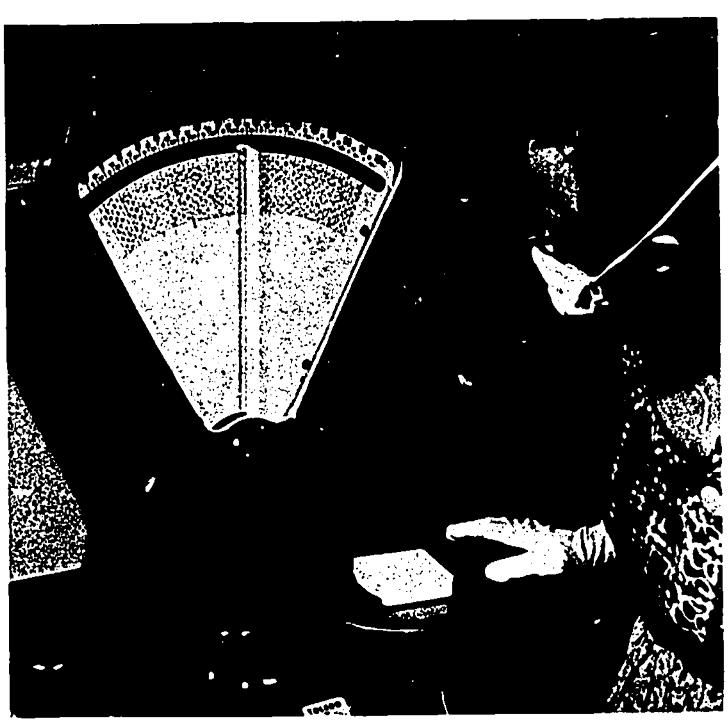


Fig. 24-4. Many materials are bought by the pound. If the estimator can figure the weight of the product to be made, he can make an accurate estimate of the cost of materials.

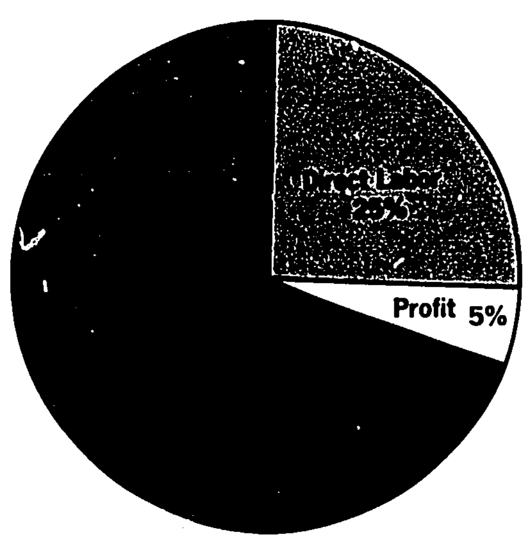


Fig. 24-6. Most cost estimates are made by adding material cost, direct labor cost, overhead, and profit. Overhead includes the cost of supervision, taxes, equipment, depreciation, inspection, sales, utilities, and many other factors.

to any one product. Instead, an allowance called *burden* (*overhead*) is added to the estimate to make up the pay of these *indirect workers*. Also included in the overhead is a charge for *auxiliary* (extra) *services*. Auxiliary services include worker recreation, office supplies, utilities, and equipment and building maintenance. Finally, a charge must be added for *profit*.

The *total estimate* includes:

1. Charges for materials to make the product,
2. Charges for the direct labor of the production worker,
3. Overhead, and
4. Profit. (See Fig. 24-6.)

The overhead charge is usually added as a percentage of direct labor. It must be figured from the past records of a company. Most people are surprised to learn that the overhead charge for many industries is about 200% of direct labor.

When Costs are Estimated

Cost estimates are made at different steps in manufacturing. The product designer may have cost estimates made for different designs to help him choose the best design solution. When the manufacturing engineer is planning production, he needs cost estimates to help choose the best processes. Cost estimates are often made during production to find more efficient methods.

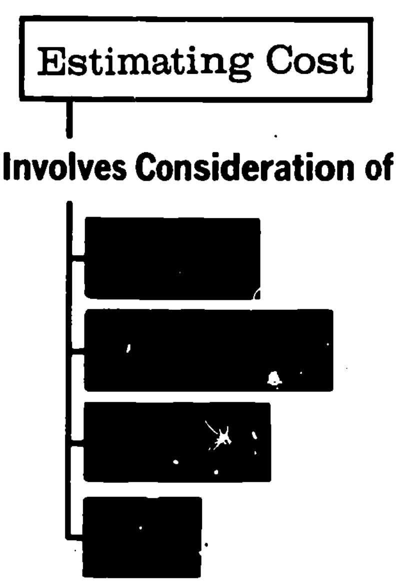
Cost estimating is an important management job. It is used at all levels of management in all kinds of industries. Top management men use cost estimates to help them decide when to build new plants or manufacture new products. The manufacturing engineer uses cost estimates to help him choose the best processes. *Budgets* (plans for spending money) for future operations of a firm are made from cost estimates of the total operation of the company.

Summary

Most manufacturing decisions are made only after cost estimates are made. There are several ways to estimate costs. The most common way in manufacturing is to add estimated charges for materials, direct labor, profit, and overhead. More efficient production methods are found by using cost estimates.

Terms to Know

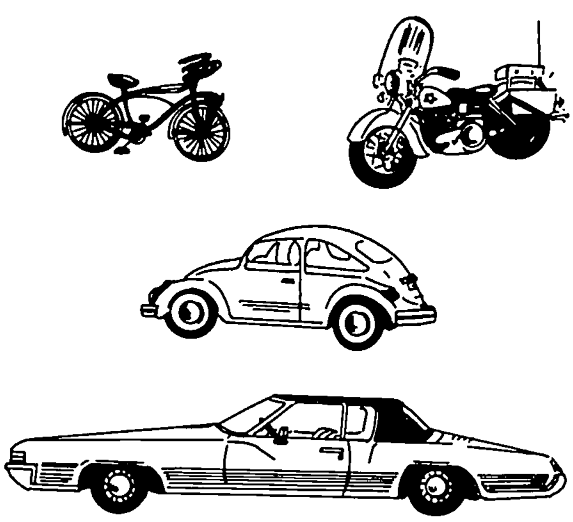
estimates (predicts)	direct labor
cost estimates	standard data
forecast	goods
approximations	services
economical	burden
selling price	overhead
cost estimator	indirect workers
cost finding	auxiliary services
evaluate	profit
material costs	total estimate
calculate	budgets
labor costs	estimators
	fatigue allowance

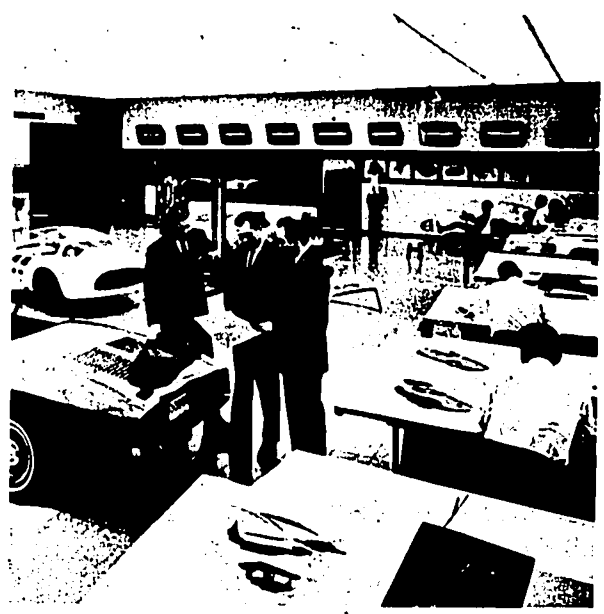


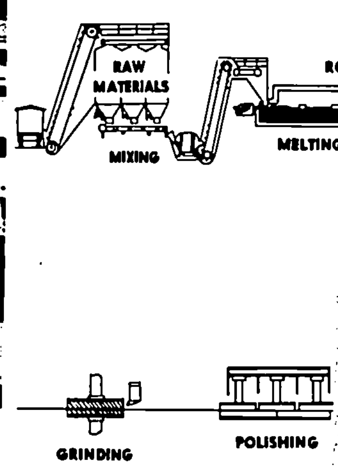
Think About It!

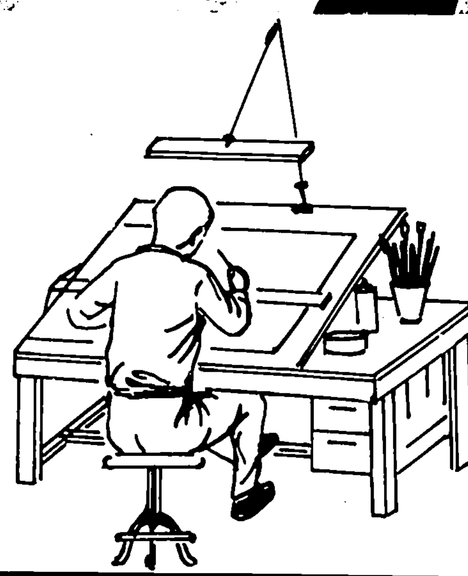
1. Why are *estimators* very important to shops that do contract work?
2. What kinds of jobs in your community would have a high *fatigue allowance* (time for workers' rest)? What kinds of jobs would have a low fatigue allowance?

Man Plans,

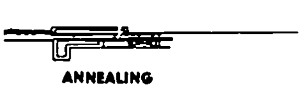


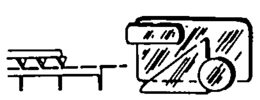


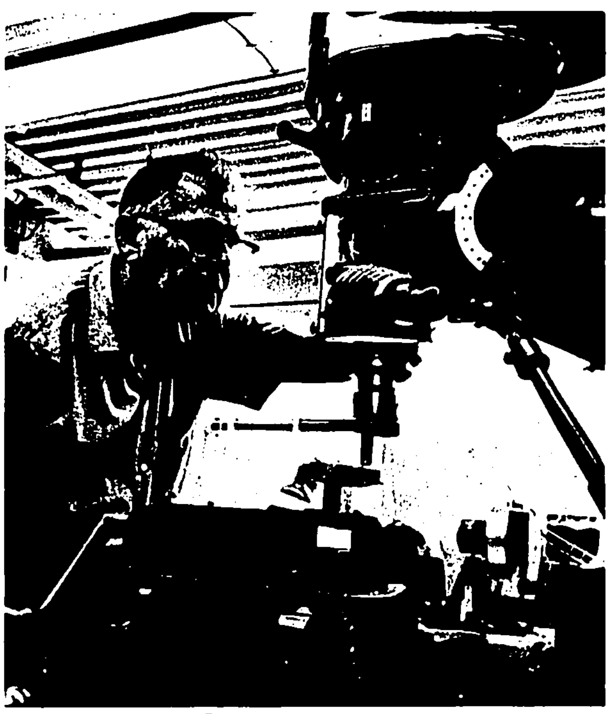


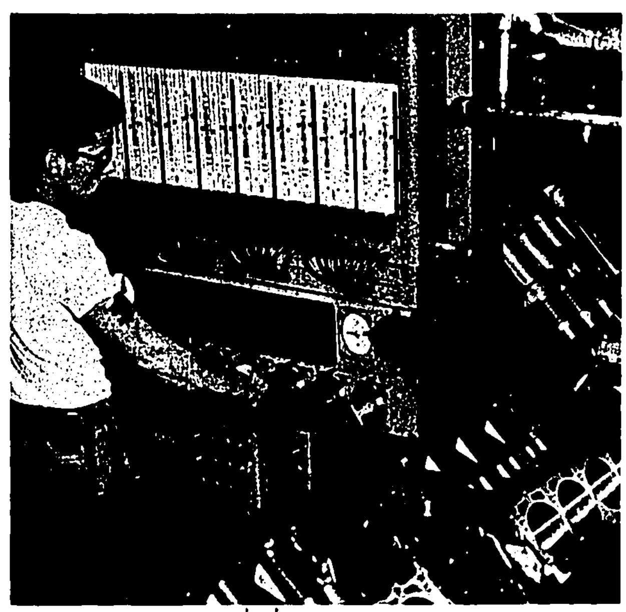


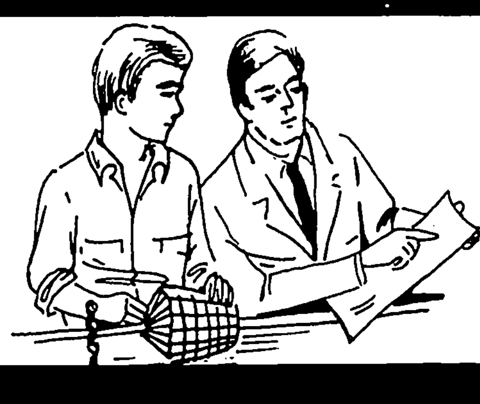
Organizes, ... and Controls Production











READING 25

Tooling-Up for Production

You have read about making a product design, deciding on the processes by which the product is to be made, and estimating the production costs. In this reading you will learn about an important activity known as *tooling up for production.*

Tooling-Up Defined

Tooling-up includes four major engineering jobs:

1. Deciding what machines, equipment, and tools will be needed.
2. Choosing and ordering all standard machine tools and equipment.
3. Designing and ordering any machines, tools, and equipment which must be specially made, Fig. 25-1.
4. Supervising the installation of machines and equipment, the start up, and the trial run of production.

For a new plant, or a plant tooling up for a new product, large machines and heavy equipment are needed. There are also dozens or even hundreds of smaller tooling items. Engineering jobs include choosing, ordering, and installing them.

For example, every plastic toy, toothbrush handle, or plastic dish needs *dies.* These dies must be made to an exact size and shape, Fig. 25-2. The die may cost only $100, or it may cost $10,000.

Dies are also needed for punching out and forming sheet metal parts. Sheet metal parts are needed for many products from can openers to light switches. *Patterns* of wood or metal are needed before castings can be made for pumps, scissors, or gears, Fig. 25-3. *Printing plates* and *cutting dies* are needed before a cereal package can be made.

In the machine shop, *jigs* are needed to hold a part and to guide a drill to its exact

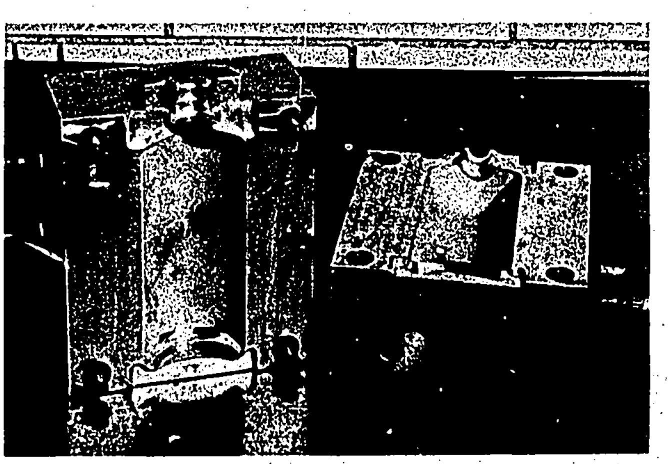


Fig. 25-1. When high-speed production is needed, special tooling is often used. This blowing mold is used in the production of a plastic bottle.

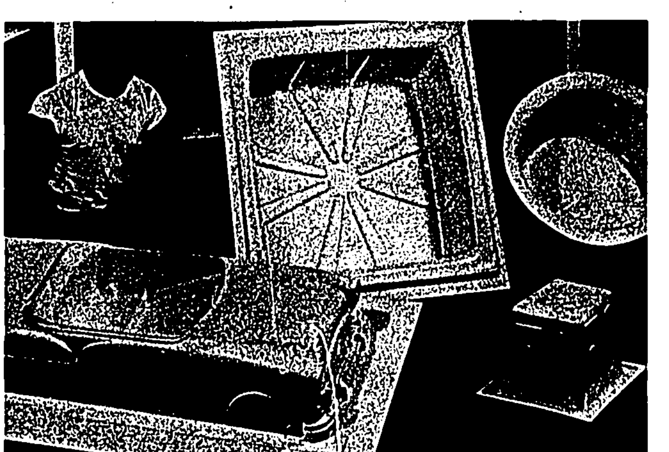


Fig. 25-2. Getting the dies and molds for forming these products is a part of tooling-up for production.

location, Fig. 25-4. *Fixtures* are needed to hold a workpiece tightly on the machine in the right location and position, Fig. 25-5. The *tapes* for numerically controlled (automated) machines must be punched out. These tapes may be short, or they may be over a thousand feet long. The long tapes are made at a very high speed by a computer. Specially designed *cutters* are often needed for machines such as lathes, boring machines, or numerically controlled machines.

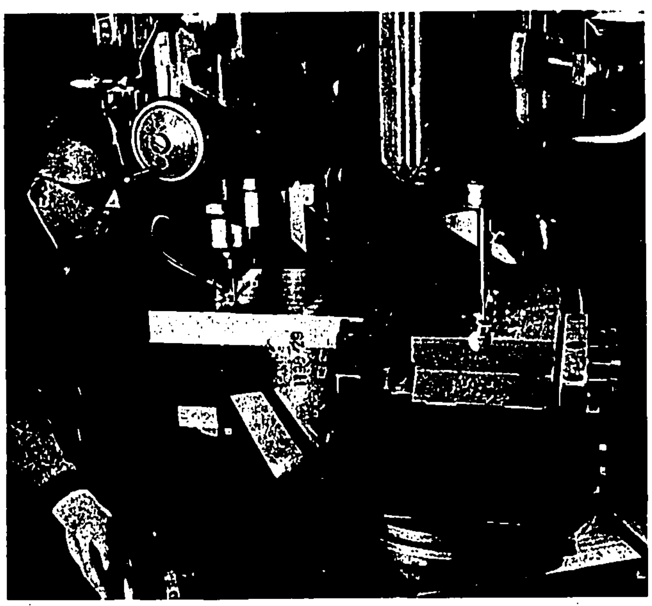


Fig. 25-3. The making of special tooling, such as this die, is a part of tooling-up for production.

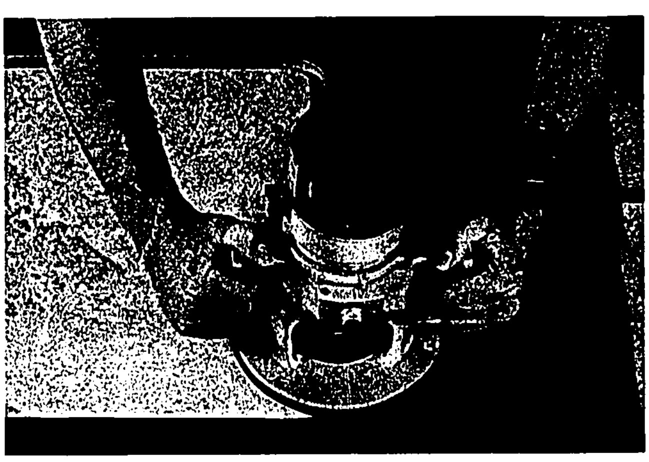


Fig. 25-4. The use of jigs to guide the tool increases production. It reduces layout time and improves accuracy.

Gages and other measuring devices are a special group of tools needed for manufacturing, Fig. 25-6. For example, the dimensions of a part coming off a production line must match the dimensions shown on an engineering drawing of that part. Gages are used to check these dimensions at cer-

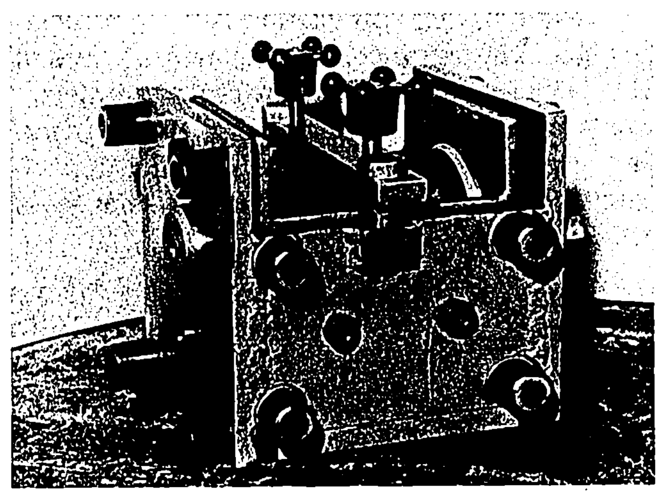


Fig. 25-5. The process of tooling-up includes getting the fixtures that are needed to hold the work on a machine.

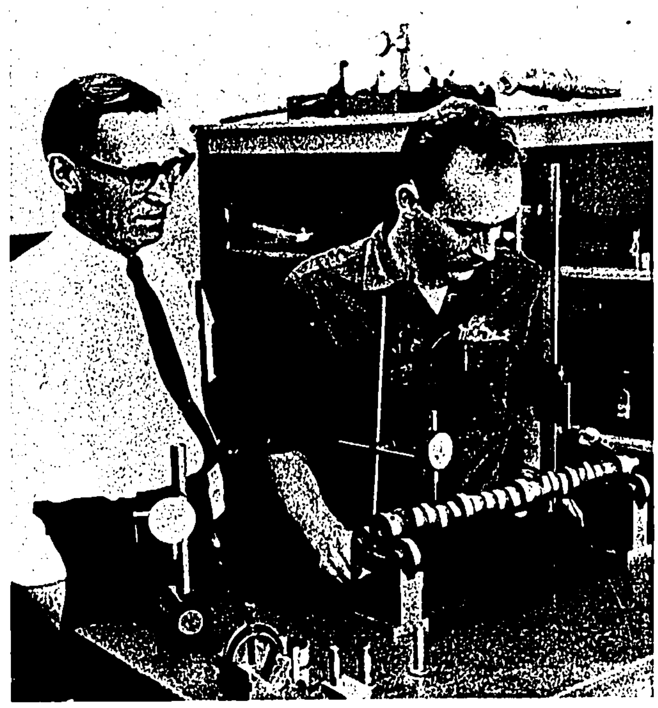


Fig. 25-6. The industrial engineer gets standard measuring devices for production.

tain times during production, Fig. 25-7. Measuring devices are important tools for *quality control.* The engineer must think about all of these when he is tooling up for production.

Tooling-Up Done by Engineering

Tooling up for production is an engineering job. The engineering group in charge of the job is not the same in every company. Some companies have a separate engineering department. The head of this department, then, would probably be in charge of the complete job.

Study the chart in Fig. 25-8. It shows a usual tooling-up process. In a small company one man might do all the work. In a large company the work might be divided among several engineers. So, the manufacturing engineer is often in charge of the *overall flow* of materials through the manufacturing plant. He will *specify* (select) some equipment, production processes, and the placement of all machines and equipment in the proper areas of the factory.

The process or methods engineer is often in charge of specifying in more detail the operations that will shape and combine product parts. He chooses special machines, jigs, fixtures, tooling, and details of production processes.

These men must cooperate (work together) closely in order to find the best way to solve tooling up problems.

Reasons for Tooling-Up

Tooling-up may be a small job done by a junior engineer in a few hours or a large job needing the work of several engineers for many months. Some of the situations calling for tooling-up are discussed below.

When a *new* company or plant is started, tooling-up is a big job. It includes *specifying* (selecting) and ordering lathes, drill presses, numerically controlled machines (Fig. 25-9), punch presses, conveyors, tanks, ovens, weaving looms, or printing presses. The engineer must know a great deal about

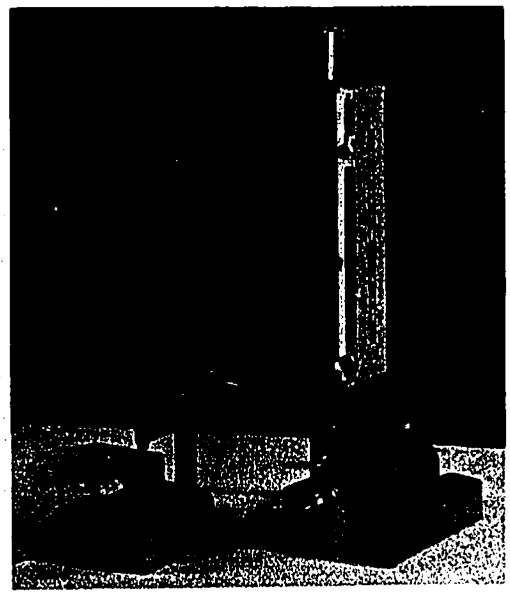


Fig. 25-7. When special measuring devices are needed for production, the engineer may have them made or he may buy them.

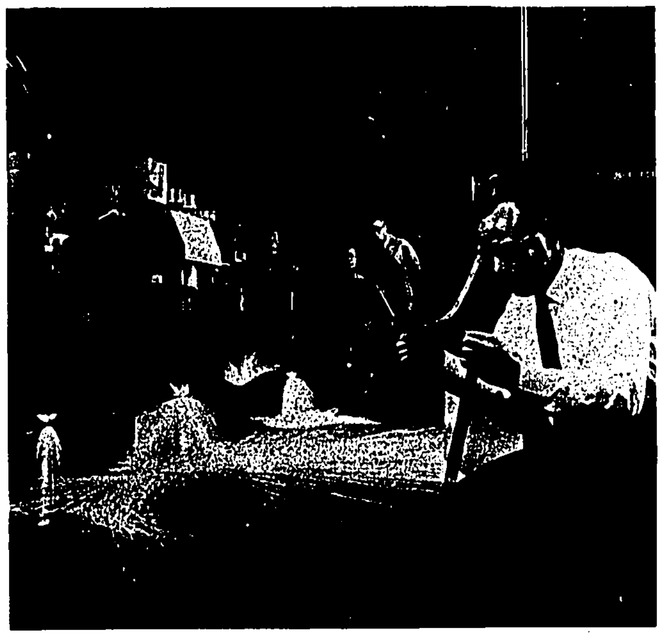
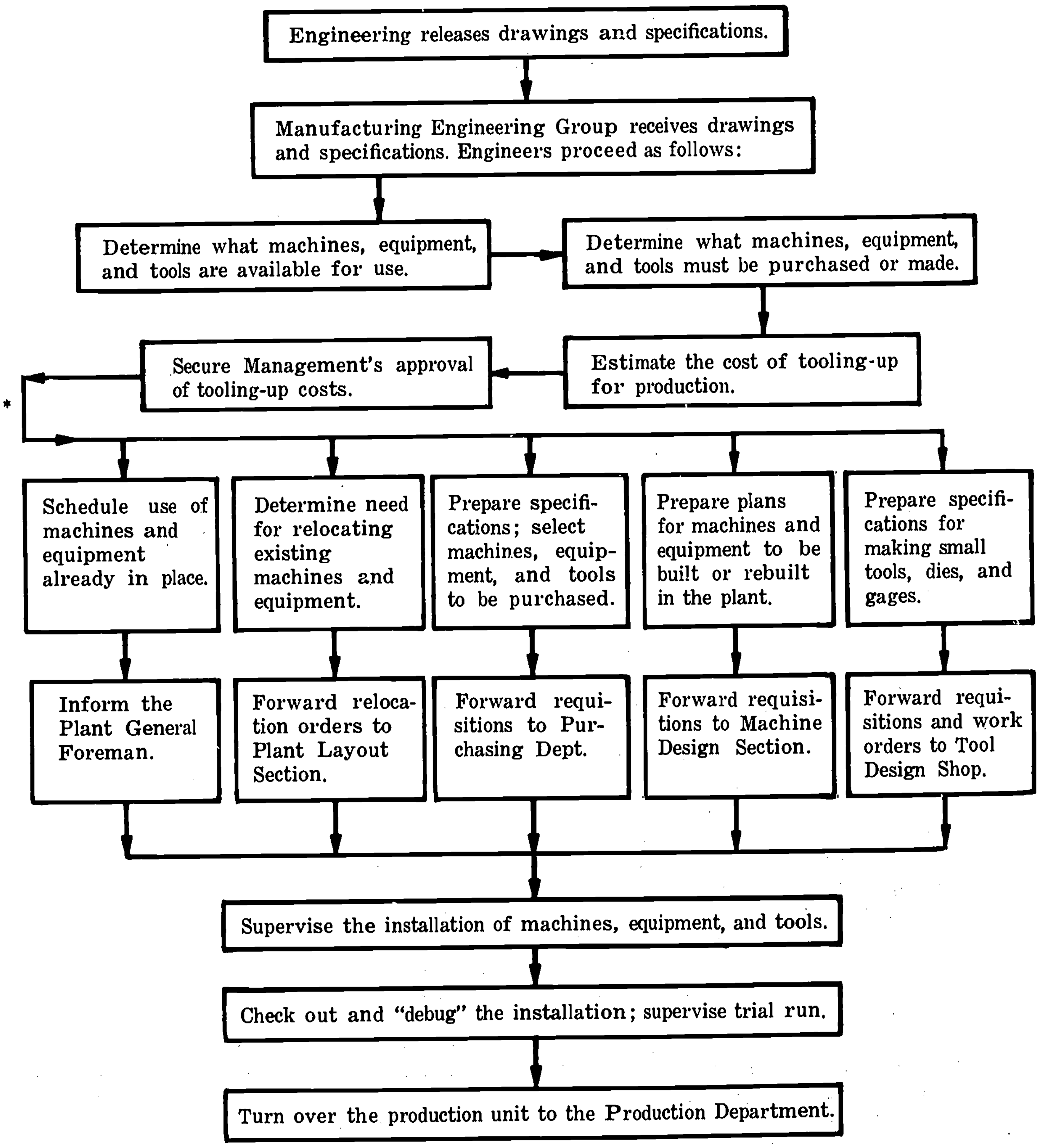


Fig. 25-9. Getting the tapes to control this numerically controlled flamecutter is a tooling-up operation.

Role of a Typical Manufacturing Engineering Department in Tooling-Up: Preparation, Procurement, and Installation



* At this point the actual tooling-up activities begin.

Fig. 25-8. The duties of a typical manufacturing engineering department in tooling up can be seen in this chart.

the product to be made. He must also know what equipment and tools his plant will need.

Changing a model of a television set, refrigerator, or automobile often means a big tooling up job. Features such as *conveyor systems, forming dies,* and assembly lines must be redesigned or relocated. Even a small change in the design of a single part may mean changing a drill jig, milling fixture, or a numerically controlled tape.

Changing material specifications may mean major tooling changes. For example, changing the material of a television tuning knob from metal to plastic means a new die and a different machine. It may also mean a new way of fastening the knob to the shaft.

Adopting new or improved methods of production may mean spending many thousands of dollars. The tooling-up specialist needs to know about *N/C (numerical control)* or other new methods.

Steps in Tooling-Up

Many of the steps taken in a major tooling up job are shown in Fig. 25-8. During this entire job many departments and people cooperate in ways the chart cannot show. Each member of the manufacturing engineering group uses his specialized knowledge.

During the process of tooling-up, some of these specialists may suggest ways to improve methods or redesign a process. Suggestions are important because the right decisions made now could greatly reduce the cost of the product. Of course, lower costs increase the company's profit.

Time is also important. If a quick start-up is needed, there may not be time to wait for delivery of a new machine. Alternate methods must be used.

Summary

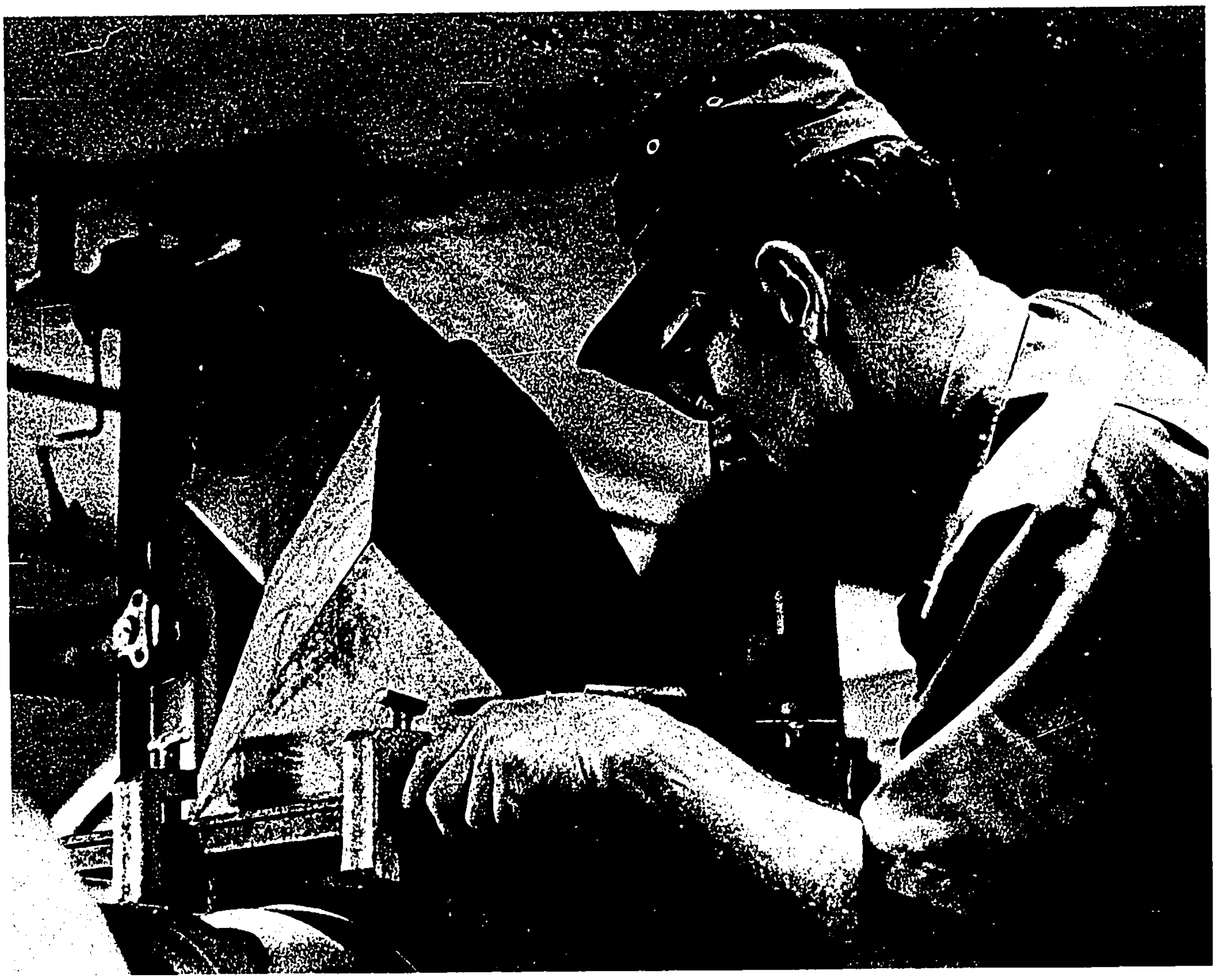
Tooling up for production must be in the charge of skillful, trained people. They are supposed to get the right machines, equipment, and tools to make a specified product. The engineers in charge of tooling-up make important decisions about the machines, equipment, and tools. Their decisions will affect the profit their company makes. Tooling-up activities in manufacturing firms usually replace or change the basic equipment already in place. Tooling-up may be very expensive or quite cheap. It must be done well at the lowest cost possible for both simple and complicated products. Tooling-up makes production possible. In the next reading you will learn how management controls the flow of parts and products after production starts.

Terms to Know

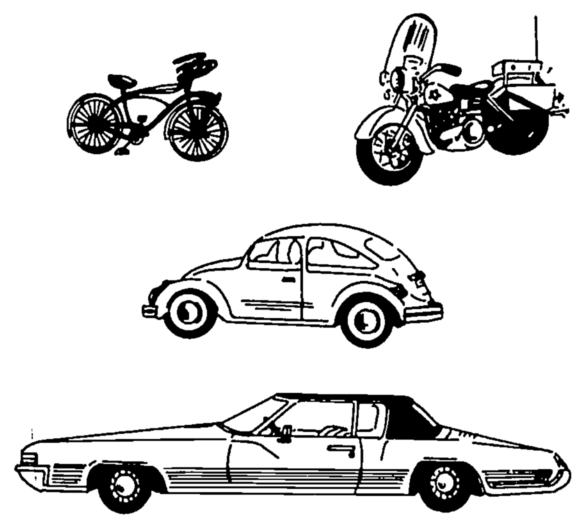
tooling-up	quality control
dies	overall flow
patterns	specifying
printing plates	cooperate
cutting dies	conveyor systems
jigs	forming dies
fixtures	material specification
tapes	numerical control (N/C)
cutters	dimensions
gages	

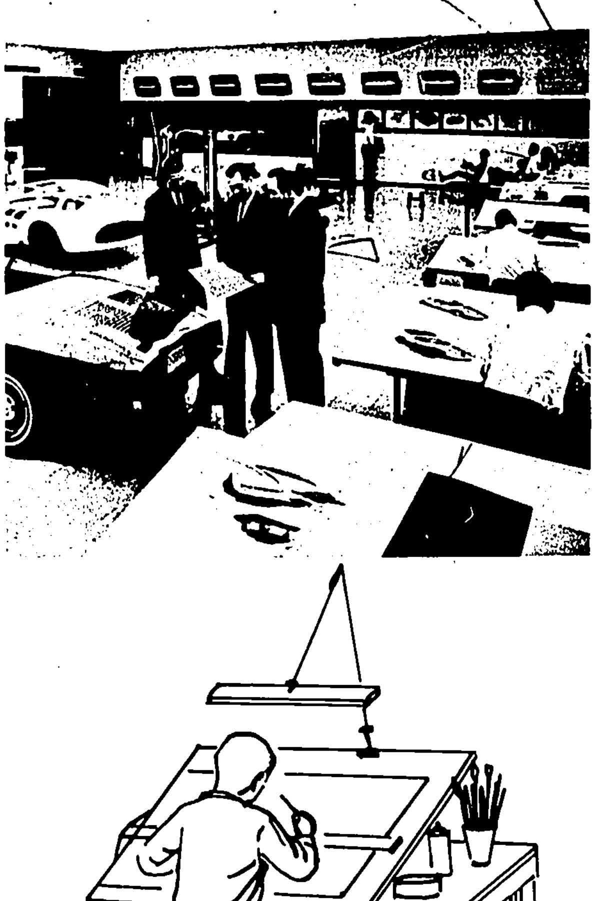
Think About It!

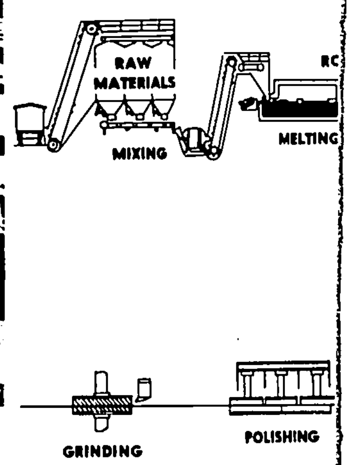
1. What would happen if the *dimensions* of a part coming off a production line do *not* match the dimensions shown on the engineering drawing for that part?
2. What *tooling up* changes would have to be made if a television manufacturer wanted to make a television model that would have a larger viewing screen than any of his other models?



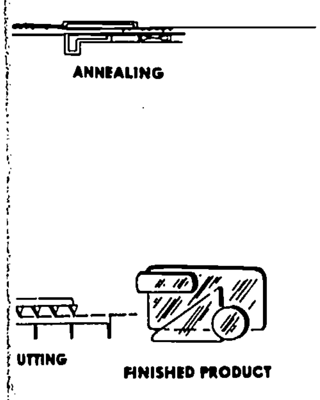
Man Plans,

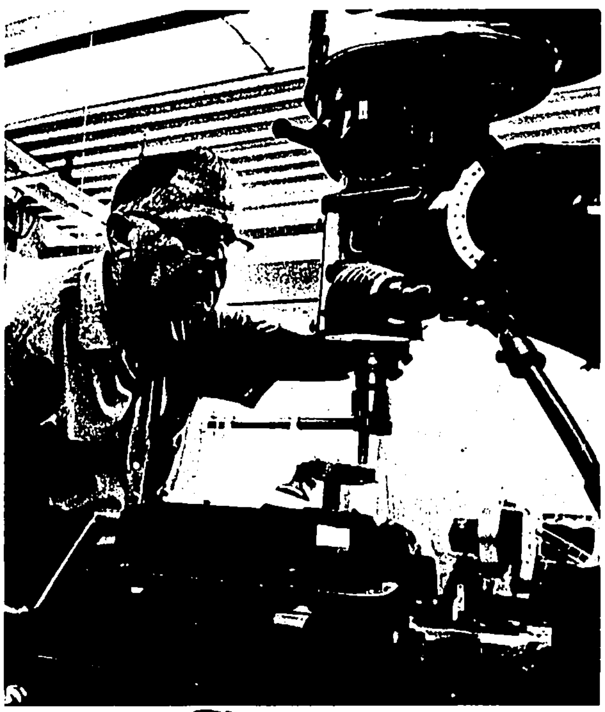


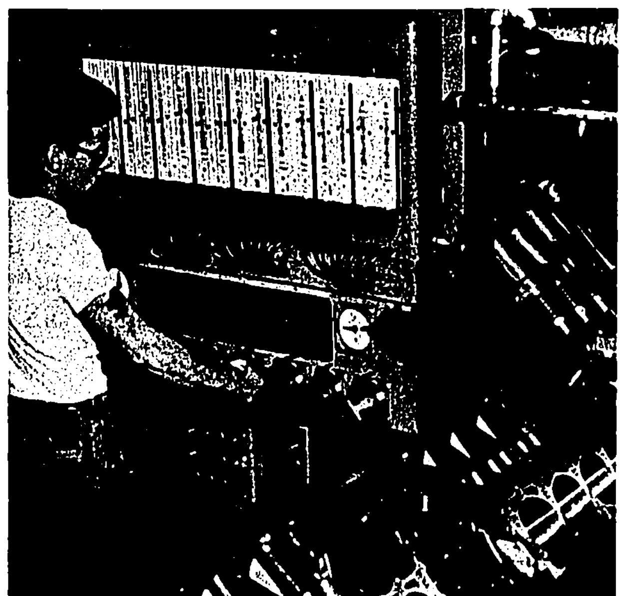


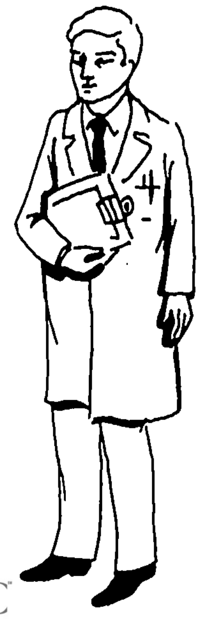


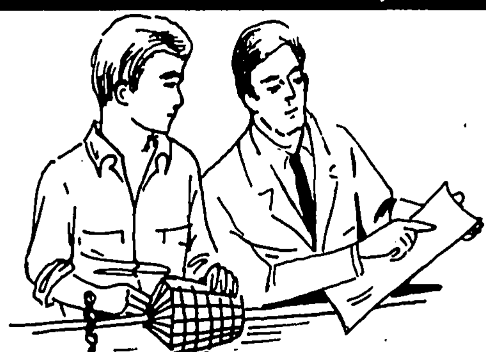
Organizes, ... and Controls Production

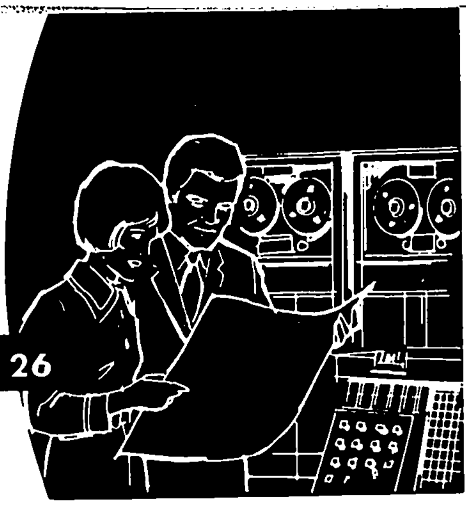












READING 26

Installing Production Control Systems

A manufacturing company is like a river system fed by many streams. The materials and purchased parts flow together to form small rivers. The rivers flow together at various stages of manufacture. After processing and final assembly, the product flows out to an "ocean" of customers. Management must keep all the materials flowing through the production sequence. These management activities are called *production control.*

Planning for the control of production starts many weeks or months before production begins. Production control makes sure that the right *material* in the right *amount* is at the right *place* at the right *time,* Fig. 26-1. Anything that keeps this from happening is a *production control problem.* The men who solve these problems work closely with the *personnel* (employment) *department,* the *purchasing department,* and with several other groups in the company.

Importance of Production Control

Production control reduces waste of several kinds:

1. The waste of space when extra quantities of material take up storage room,
2. The waste of time when workers are idle, and
3. The waste of time when machines or whole production lines are shut down.

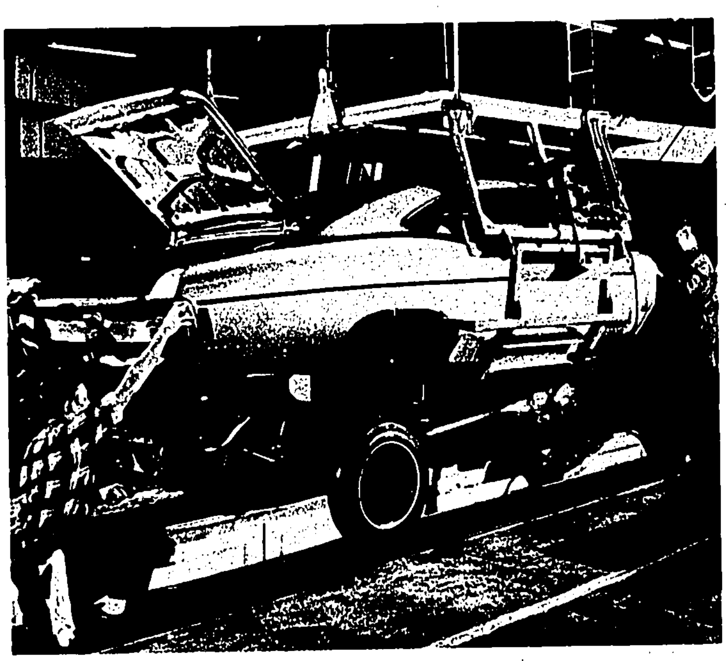


Fig. 26-1. Individual parts and subassemblies must arrive at the final assembly line in the correct order. The next car may have a different engine or be a different color.

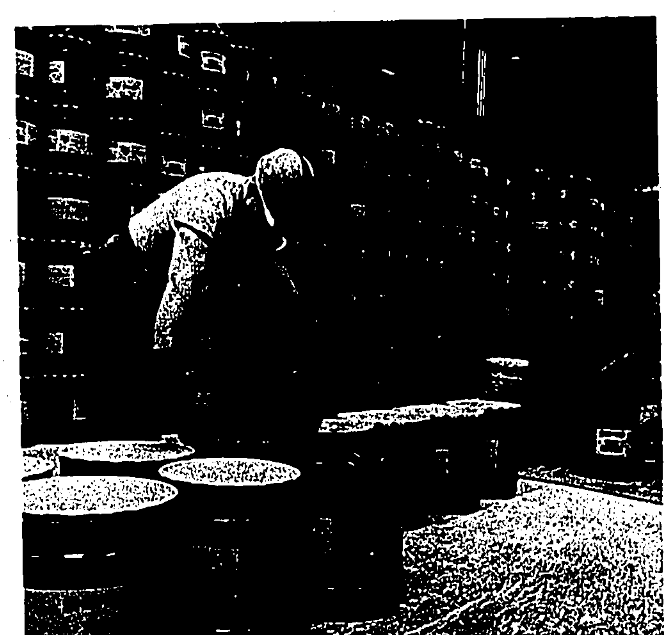


Fig. 26-2. Some parts are manufactured in large quantities and stocked. Customer orders are filled from this stock.

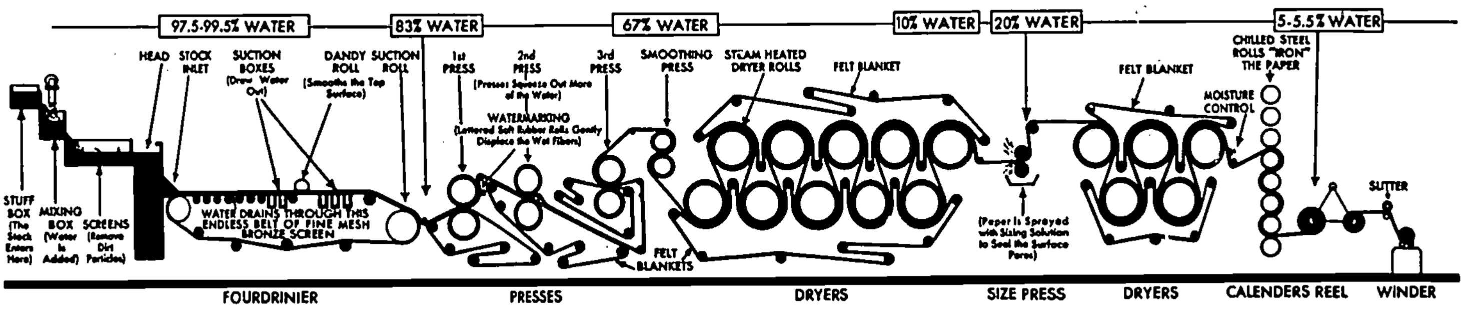


DIAGRAM SHOWING HOW PAPER IS MADE ON A MODERN FOURDRINIER PAPERMAKING MACHINE

Stock Production and Order Production

Management usually knows what it will do with the finished product. Customers may have already ordered the product. Management may be fairly sure that orders will be coming in. If production starts only after an order comes in, it is called *order production.* If the product is to be stored to wait for customer orders, manufacturing begins (or continues) for *stock.*

There will usually be customers for certain products, Fig. 26-2. Products like shoes, towels, canned peaches, or aspirin may be manufactured for stock. In fact, most of the manufactured products you use are made for stock, and they are available upon customer demand.

Some products are not actually made until a customer has ordered them. Perhaps the product is very expensive, Fig. 26-3. Perhaps there will be several slightly different forms of the product. Sometimes the customer asks for certain product details. Equipment for underground coal mining is this kind of product. The kind of equipment the customer needs will depend on the depth and thickness of the coal vein. The manufacturer and customer must work closely together to get the right machinery ordered. Then the large, expensive pieces of equipment are manufactured. This is *production for order* (*to order*).

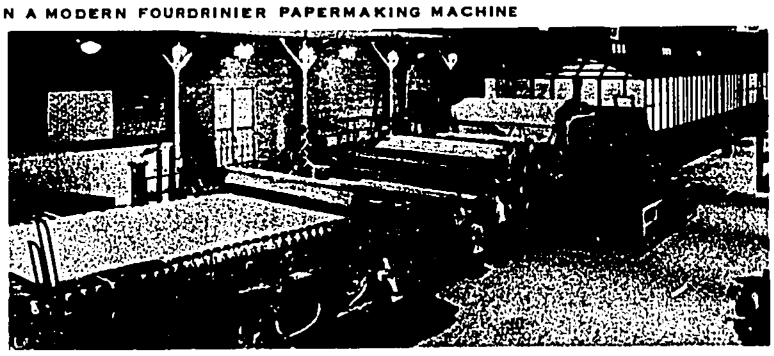


Fig. 26-4. Many products are made by continuous processes. Raw materials go in one end of this machine and finished paper comes out the other.

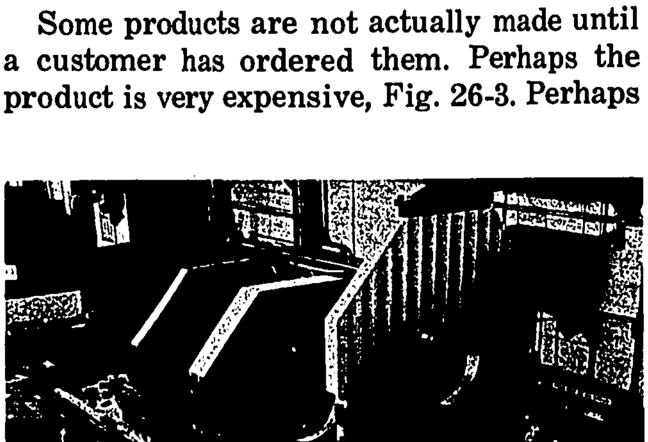


Fig. 26-3. Only one of this magnet assembly for an atom smasher will be built. Machines of this kind are made after a customer has placed an order.

Continuous, Custom, and Intermittent Production

Continuous production (production that goes on all the time) is common in plants where large numbers of products are made. Often this kind of production is called *mass production.* Continuous production is common in the steel, chemical, petroleum, and paper manufacturing fields, Fig. 26-4. In

these plants, materials are processed for the future use of other manufacturers. Continuous production is also common in assembly plants. In these plants, thousands or even millions of the same product are made each year. Usually, continuous production is production for stock, because the product is consumed rapidly.

Custom production is planned to fill a customer's order, Fig. 26-5. It is often called *jobbing (job shop) production.* The number of products made is usually low. A manufacturer, however, sometimes decides to make an item or a small number of items for stock. This may also be called *custom production.*

Production is *intermittent* if it starts and stops at different times. Suppose the number of sales for a product is not high enough for continuous production but too high for custom production. Then the manufacturer will plan *intermittent production.* Intermittent production has one advantage. The same equipment may be used to manufacture several different products. Only a small change of input or machinery is needed. For example, the machinery that bottles and sterilizes baby food can process several kinds of baby foods. A change from applesauce to banana pudding might mean changing processing temperatures, but the same machinery would be used, Fig. 26-6. Intermittent production can be planned to fill an order or to build up stock.

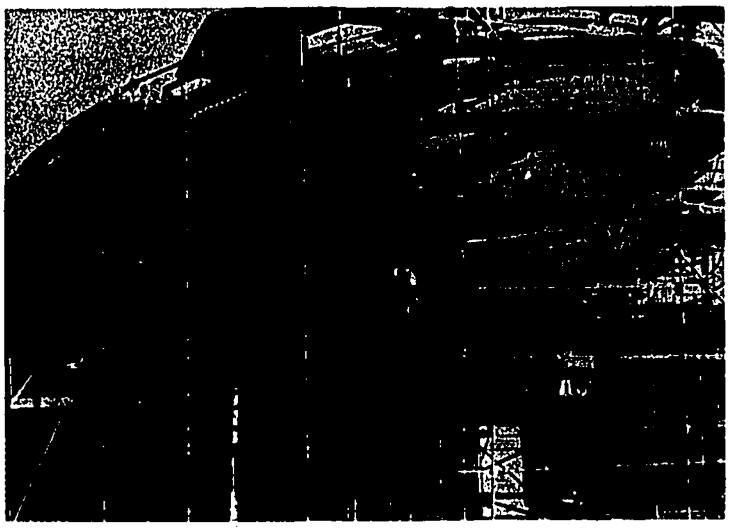


Fig. 26-5. Every ocean liner is produced *for order.* Each liner is made to exact *custom details.*

Types of Production Control

A manufacturer chooses the kind of production control that best fits his own kind of production. *Order control* and *flow control* are two of the most common kinds of production control systems. Other kinds include *batch control, block control, load control,* and *special project control.*

Practices of Order Control

Usually, custom and intermittent production use a kind of production control called *order control.* Intermittent production often uses general-purpose machines. Many different products can be made on these machines by skilled machine operators. *Custom* (made to order) *shops* and general machine shops both use order control.

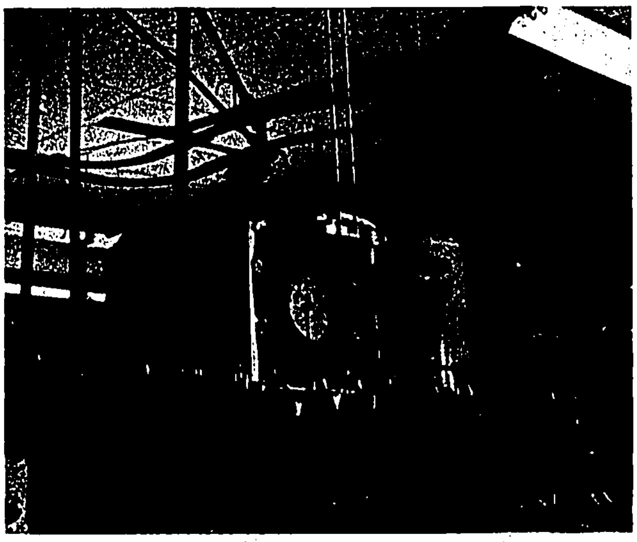


Fig. 26-6. Large quantities of one kind of soft drink may be produced with this machine. The contents and bottles may be changed for a different kind of soft drink. This is one kind of intermittent production.

Order control usually goes through the following steps:

1. Making up bills of material,
2. Setting up route sheets,
3. Scheduling,
4. Dispatching,
5. Monitoring,
6. Reporting, and
7. Correcting.

Production planning and production control are done at the same time. Order control starts with order planning and organizing. First the customer's order is studied. Then a *bill of material* is *issued* (written up). This bill of material lists amounts of the different materials needed, Fig. 26-7.

Next, *route sheets* are set up to show in the right order the operations needed to complete the order, Fig. 26-8.

BILL OF MATERIALS

Assembly Name Midget Water Purifier Model Number 13
Quantity 2,000 Drawing Number 6819
Date June 25, 1971 Sheet 1 of 1

Part Number	Part Name	Units Required	Unit	Inventory Code No.
1	Body	2,000	ea.	363
2	Base Container	2,000	ea.	126
3	Neck Funnel	2,000	ea.	427
4	Cap	2,000	ea.	226
5	Cap Hinge	2,000	pair	541
6	Cap Lock	2,000	ea.	143
7	Filter	4,000	ea.	106
	Purification Granules	1,000	lb.	71

Fig. 26-7. This bill of materials lists the numbers of each part needed to fill the customer's order.

ROUTE SHEET

Part Name Cap Plate
Part Number A
Material Cast Aluminum

Part Number A-24
Drawing Number 1317
Date Effective June 25, 1971
Sheet 1 of 1

Operation No.	Description of Operation	Machine	Tools, Jigs, etc.	Std. Time (min) Setup	Prod.	Oper. Spec.
A 24-1	Face surfaces	Lathe	4-jaw independent chuck	10	10	
A 24-2	Drill 4 holes 1$\frac{1}{64}$″	Drill	1$\frac{1}{64}$″ T. S. Drill	10	10	
A 24-3	Counterbore 4 holes 1$\frac{1}{4}$″ by $\frac{1}{8}$″ deep	Mill	1$\frac{1}{4}$″ C' Bore with $\frac{5}{32}$″ pilot	6	6	
A 24-4	Press part number on outside	Arbor Press	Jig #A-24-4	4	2	

Fig. 26-8. This route sheet shows the correct order of the operations needed to complete the customer's order.

The next step is *scheduling*. The time needed for each operation is figured. Then, a timetable is set up for completing the product in the amount ordered. The schedule shows dates for ordering and receiving all necessary inputs, for starting production of parts, for subassembly, and for final assembly operations, Fig. 26-9.

Fig. 26-9. If parts have not been scheduled correctly, white refrigerators may end up with green doors.

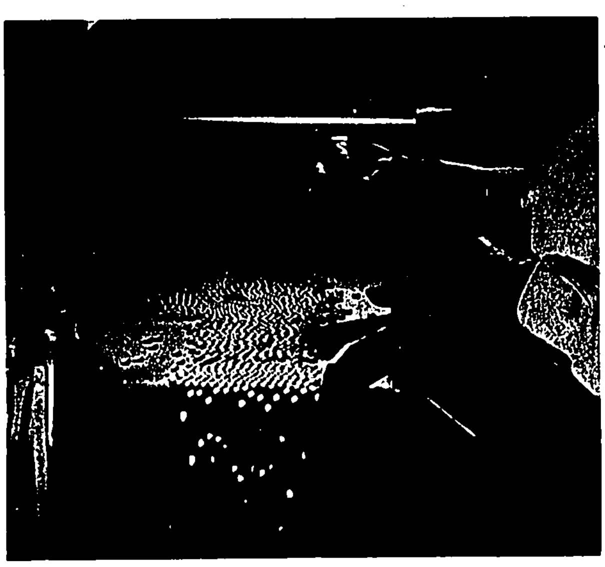


Fig. 26-10. Inspection is part of monitoring. The right quantity and quality must be produced.

Dispatching is next. It includes making up work orders, job orders, or factory *releases*. These orders release (let go) material from storage in order to start production and are called the *activating orders*. They form the dividing line between production planning and production controlling. *Controlling orders* begin after the material starts moving through the production system.

Monitoring means checking the work performance. It also means comparing the product with the details of the original production plan. Both the quality and quantity of a product are checked, Fig. 26-10. The production performance is recorded on a chart.

Reporting means telling people with *authority* (those who can maintain production or change it) whether production is going according to plan. *Correcting* means making any changes that are needed.

Practices of Flow Control

The *flow control* system is simpler than the order control system. No routing sheets are needed. The routing was figured out when the processing equipment was designed. Thus the production plan only includes:

1. Figuring out the quality and quantity of the output,
2. Getting the necessary inputs, and
3. Making out material releases.

The control plan keeps production moving at the right rate and with the right quality.

Continuous production uses special purpose machines and equipment. They do only one operation. Semiskilled operators can be hired to run them. Oil refineries, chemical plants, and some food processing plants are examples. *Flow control* is best for this kind of production.

Other Kinds of Control

Many food processing plants use what is called *batch control*, Fig. 26-11. Only one set of *ingredients* (materials) is used to make

one batch of the product at a time. Examples are baking bread, cookies, or cakes. Each of these products is made from a *recipe* (a list of ingredients with the amounts to be used and the order in which they are to be used). The same recipe may be used continuously or several recipes may be used intermittently.

Textile industries use a *block control* system. For example, with this kind of control, a block of 100 shirt backs, collar pieces, pockets, left and right fronts, and left and right sleeves can be cut out in one size. This block of parts can be sent to *assembly* (sewing) while a block of parts for a different shirt size is being cut out.

Newspaper printing is done by *load control.* Every page must be run through the printing presses, so the press speed and setup time control the production system. All work that gets the pages ready to print must meet set *deadlines* (time limits). Otherwise, the newspaper cannot be printed and delivered on time.

Special project control is used for products like spaceships, lunar transport vehicles, and nuclear submarines. It is very important for these vehicles to be safe for the people who ride in them.

Inventory Control

The word *inventory* has several meanings. Sometimes it means all the property owned by a company. It can include plants, equipment, raw materials stored for processing, or finished products held in stock. When a factory manager speaks of his *materials inventory,* he is talking about the exact amounts of all the materials in storage.

The word inventory also means a *record.* This record is a list of items and quantities carefully arranged in a useful way, Fig. 26-12. Inventories may be arranged in many useful ways. The system of record-keeping that a company uses depends upon the kind of products it makes.

Taking inventory means counting the number of products and materials in the plant. Most companies take inventory at regular times (once every week, once every month, or once every year). *Controlling inventory* means planning ahead so that there will always be enough materials and tools on hand.

Controlling inventory is very important. In a large plant it can be a large and compli-

Fig. 26-11. Candy is produced in batches. The ingredients in each batch must be controlled.

Fig. 26-12. Records must be kept of the material in process as well as material ready for shipment. This is part of inventory control.

cated job, Fig. 26-13. Suppose a single machine shuts down because there is no replacement for a worn-out part. The factory's whole production schedule may be upset. Suppose the supply of one raw material runs out. Production may stop until a new supply arrives, Fig. 26-14. Inventory control personnel must look ahead. They must know what will be needed next week or next month. For example, suppose the cutting blade on a machine always wears out after a few days' use. A supply of replacement blades must be kept on hand. Suppose next month's production of axes is to be painted red. The red paint must be ordered in time to be checked for color matching. Otherwise, it won't be ready for use on time.

Summary

Production control personnel must plan for, organize, and control the flow of materials through all production processes. They work closely with other groups to keep machines running and to use manpower efficiently.

The schedule for production flow depends upon customer needs, sales volume, and other factors. Production often does not start until an order is received. Often it goes on steadily, keeping ahead of orders. One production line may make a single item for many months. Another production line may be used to manufacture many different items.

The kind of production control system used depends largely on the number and kind of products made in the plant. Order control is widely used in custom and intermittent production. Flow control is common in continuous production. Control may be by batch, block, or load. Where human safety is needed, special project control may be used.

Production planning and production control go on together. Production control usually starts when the wheels of manufacturing start to turn. But much work is done by production control engineers before that time. Production control may mean:

1. Making out orders for materials,
2. Routing and scheduling materials,
3. Dispatching job and work orders,
4. Keeping records of actual performance of men and machines,
5. Comparing these performances with the original plan, and
6. Starting corrective action when necessary.

Fig. 26-13. Modern industries use computers for production control and inventory control.

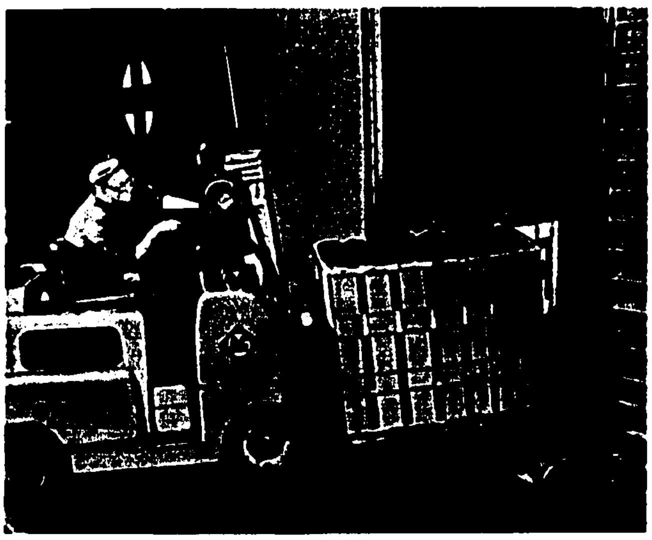
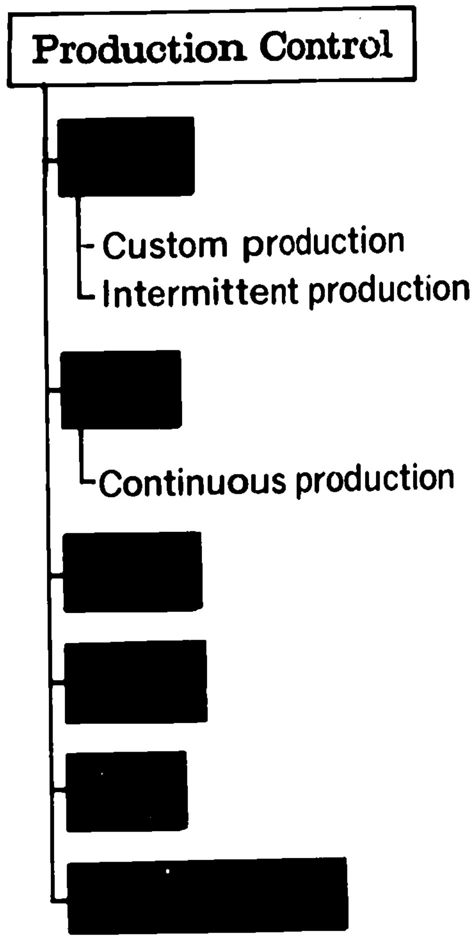


Fig. 26-14. Production control makes sure the right number of the right parts are ready to be shipped to the right customer at the right time.

Production control depends a lot upon controlling inventory. The right material in the right amount must be in the right place at the right time.



Terms to Know

production control
production control problem
personnel department
purchasing department
order production
stock
production for order
continuous production
mass production
custom production
jobbing (job shop) production
intermittent
intermittent production
order control
flow control
batch control
block control
load control
special project control
custom shops
bill of material
issued
route sheets
scheduling
dispatching
releases
activating orders
controlling orders
monitoring
reporting
authority
correcting
ingredients
recipe
assembly
deadlines
inventory
materials inventory
record
taking inventory
controlling inventory

Think About It!

1. What kinds of manufactured products can you think of that would be processed by *mass production?* by *custom production? by intermittent production?*
2. What kinds of materials would you find in the *inventory* of a bakery?

READING 27

Operating Quality Control Systems

If a product has been poorly designed or produced, there is a lot of waste. The company has lost the cost of the raw materials. It has paid wages for supervising, handling, processing, and inspecting. Now it must add all these costs to the cost of the products good enough to be sold. The cost of the scrap must also be added to the cost of the products to be sold. All this increases the price to the customer. High prices may force customers to buy from *competitors* (others who sell the same products). So quality control systems are important if a company wants to stay in business.

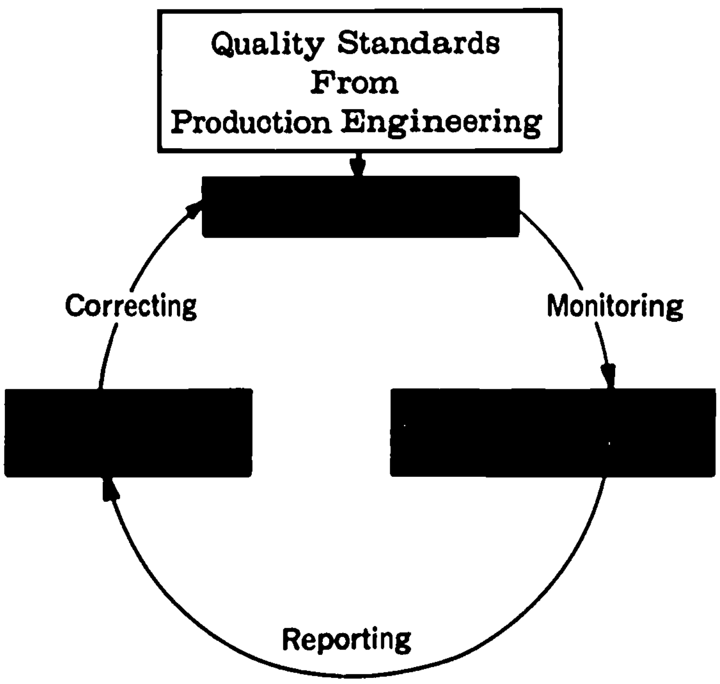


Fig. 27-1. The quality control loop makes sure the products to be sold are not poorly made.

Nature of Quality Control

Quality control may be defined as those actions needed to make sure the product is good enough to be sold. There are three main stages in the quality control system (*control loop*). These are *monitoring*, *reporting*, and *correcting*, Fig. 27-1.

Monitoring

Inspecting is one kind of monitoring. There are three main kinds of inspection: *receiving*, *in-process*, and *end-process* inspection.

Receiving inspection makes sure that the raw material and purchased parts fit the production specifications, Fig. 27-2. It answers the question: Are we getting what we are paying for? Materials are inspected when they arrive at the plant. This inspection is

Fig. 27-2. Raw materials are inspected as they are received.

done by chemical analysis, physical and metallurgical tests, checking dimensions, and counting the quantity of material received.

In-process inspection includes all the inspections made during the manufacturing process. These inspections make sure the product will be good enough to be sold, Fig. 27-3. Production workers and inspectors make in-process inspections. Production workers are in charge of product quality. Inspectors only examine and report the quality of what production workers are making. Thus, both production workers and inspectors must use similar gages and measuring instruments.

End-process inspection is the inspection that follows the completion of a manufacturing process, Fig. 27-4. The questions asked at this point are: Will it fit together with other parts? Will it work? Will it work as long as needed for customer satisfaction? Will it work at the temperatures, speeds, and loads that it is supposed to? The answers to these questions can only be had from a lot of highly specialized test equipment.

Reporting and Correcting

Inspectors first collect information on quality. Then they report the results to production control. If the product is being made according to plan, this is reported. If it is *substandard* (poorly made), this is reported.

If the product is being made according to plans, no corrective action is needed. If the product is poorly made, however, production must be stopped until the right changes can be made. Supervisors and production workers must first find the trouble. Then they must make the right changes to make sure the product is not poorly made.

Computers can play an important part in the inspecting (monitoring), reporting, and correcting loop. A computer called an *analog computer* can be programmed to tell poorly made products from good ones. Then it signals the need for corrective action.

Acceptable Quality

Products good enough to be sold are products with *acceptable quality*. There are many *standards* (rules) of acceptable quality to which products are made. There are international standards, United States stand-

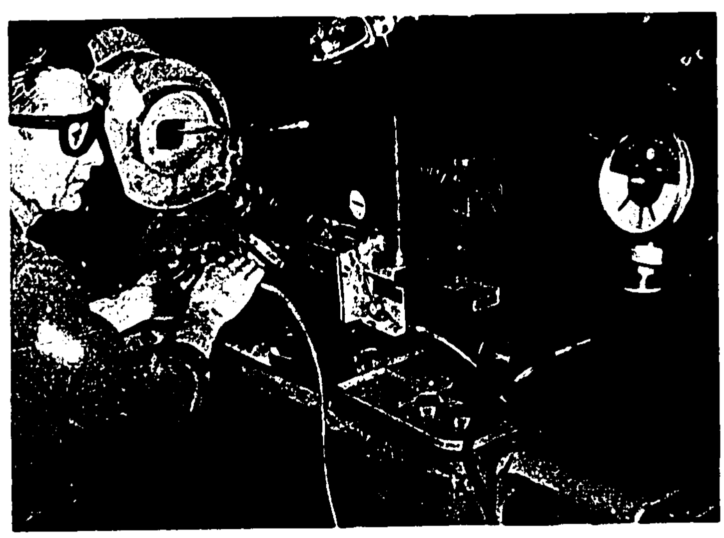


Fig. 27-3. In-process inspection is used for process control.

Fig. 27-4. Products must pass a final inspection before packing.

ards, and military standards. There are standards set up by different professional engineering groups. There are also standards set up by the management of one company. The customer has the final control on what standards are used by any company. Products made to be sold in international trade should use international standards. Products for sale to the United States government must meet United States standards. Products for sale to the public must meet standards good enough to get and keep customers.

Nonfabricated Products

Products put together from two or more mechanical parts are usually called *fabricated products*. Products of only one piece, such as a paper clip, are also fabricated products since they are formed from standard stock (wire). Products that are not made of mechanical parts are often called *process products*. Examples of process (*nonfabricated*) products are shoe polish, breakfast cereal, toothpaste, gasoline, paper, and steel.

To control the quality of process products, many features must be inspected. These features include color, taste, odor, texture, hardness, brittleness, and fluidity. The product is designed to a set of *specifications* (description of quality, number of parts, sizes, chemical formulas, and other data), Fig. 27-5. Quality control personnel run many chemical and physical tests to make sure that the quality of process products is acceptable.

Fabricated Products

The specifications and standards for fabricated products are usually given on the working drawings. Four conditions must be checked and measured for fabricated products. Three of these conditions are checked during the in-process stage. One is checked at the end-process stage.

The *condition of size* is the easiest to check, Fig. 27-6. It answers the questions: How big? How long? How deep? How thick? The *condition of shape or form* is not so easily checked. Sometimes it is hard to measure quickly, Fig. 27-7. This condition answers the questions: How flat? How rough or smooth? How nearly round? (See Fig.

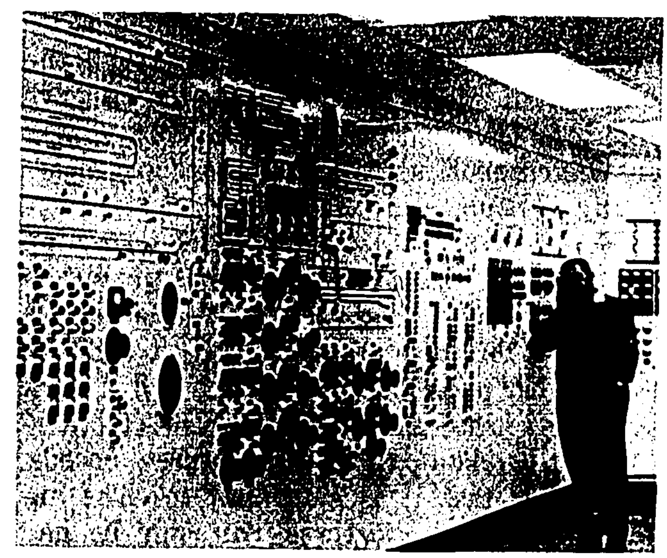


Fig. 27-5. Paint quality for an automobile plant is controlled from this room.

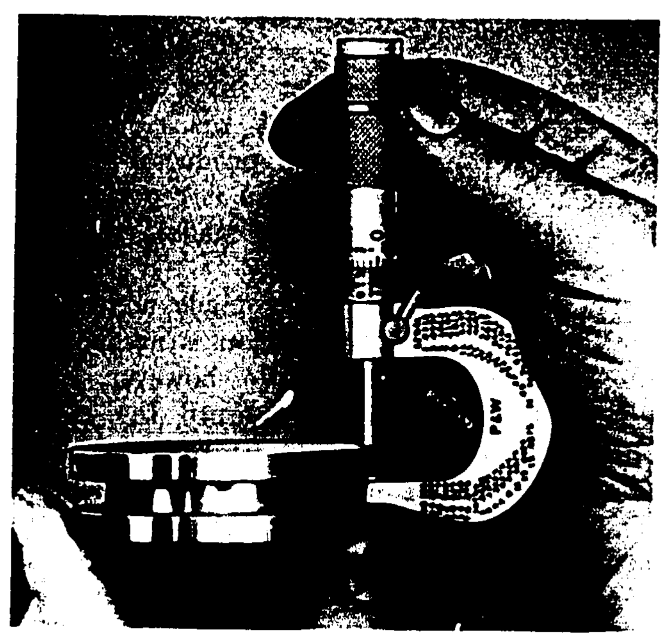


Fig. 27-6. Most machined parts are inspected for size.

27-8.) How straight? The *condition of positional relationship* checks the way two or more surfaces are related. Are they parallel? Do they meet at right angles?

These three conditions are inspected during the in-process stage of production. Both production workers and inspectors check the conditions of size, shape or form, and positional relationship.

The fourth condition is the *condition of assembly and function*. This is inspected at the end-process stage. The inspection answers the questions: Will it assemble? Will it work under the conditions it is supposed to? Will it work as long as it should? This is the "proof of the pudding" or "moment of truth." The product to be sold will be acceptable if: (1) the industrial designer has designed it well, (2) the production engineer has planned the manufacturing processes well, and (3) the quality controller has monitored the product quality well enough.

Production workers are directly responsible for quality of the product. They check their work carefully. They use the same kinds of inspection tools that quality control people use.

Interchangeability of Parts

Mass production is impossible unless all the parts of one kind are almost *identical* (the same size). All the parts must be very nearly identical so that they are *interchangeable*. To be interchangeable, any one of several thousand identical pieces of one part will fit with any one of several thousand pieces of a joining part. The joined part must then be able to do the job it is supposed to do. *Interchangeability of parts* means making quantities of any part so that any one piece can be joined to its partner without special fitting. All the pieces must fit together and work well. Parts must be *accurately* (precisely) made to be interchangeable. Thus, replacement parts can be gotten quickly and cheaply when they are needed.

Interchangeable parts are picked *at random* (by chance) on the assembly line. For example, the man on the assembly line must be able to pick up and install a fan blade that is interchangeable with thousands of other fan blades. The fan blade that is picked from the available stock must fit and

Fig. 27-7. A standards laboratory can make sure of the accuracy of electrical instruments.

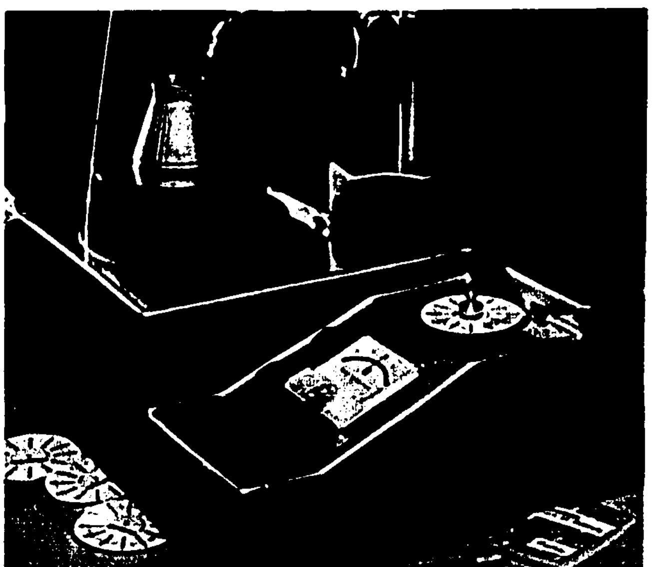


Fig. 27-8. This machine finds errors in roundness as small as one-millionth of an inch.

do the job it is supposed to do, Fig. 27-9. The factory assembly line does not allow each part to be "custom fitted."

Variations of Parts

All identical parts differ a little. There is no such thing as an exact size. For example, if 10 people marked off a distance of one-inch, there might be 10 different measurements. A microscope would show there were measurement points on both sides of a standard one-inch measure. There are many reasons for this: the sharpness of the pencil, the accuracy of the ruler, the texture of the material marked on, the quality of the measurer's vision, and the skill of the measurer, Fig. 27-10.

In industry, *variations* (slight differences in size) may happen because of wear to the machines and tools. Every time a tool cuts, or parts rub together, a very slight *abrasion* (wear) takes place. This is one reason why tools become dull and machines wear out.

While he is doing his job, a worker may make mistakes. This is another cause of variation. No two people have the same skills, so the quality of each person's work will be different. Other variations may be caused by a poor grade of materials, shrinkage or expansion of materials, or a power failure in the machine or assembly line.

Control by Sampling

When many thousands of parts are made, each individual part does not have to be inspected. If a small percentage of poorly made parts is acceptable, *sampling* inspection may be used. For example, nails may be acceptable if no more than 1% (one out of 100) have a *defective* (poorly made) head or point. The inspector might check 1000 nails *at random* from a barrel of thousands. Suppose he found only five with defective heads or points. Five out of 1000 is only one half of 1% (.005). Thus, he could safely decide that the barrel of nails was acceptable.

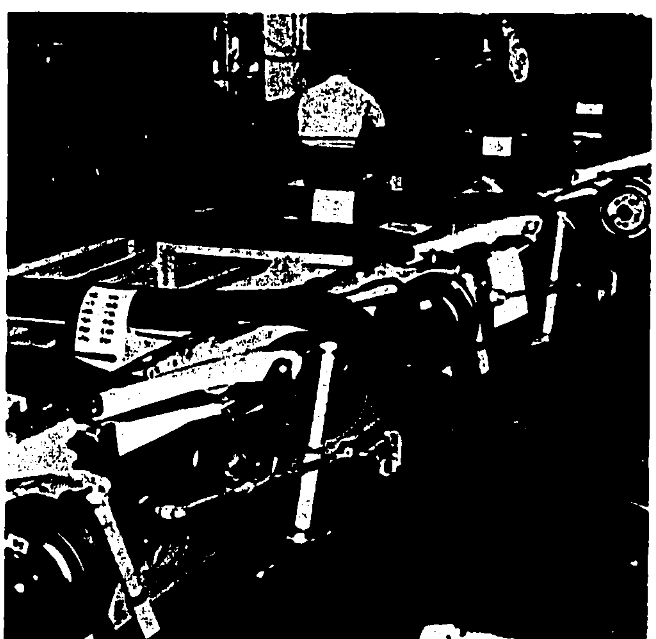


Fig. 27-9. Modern assembly lines are possible because of interchangeable parts.

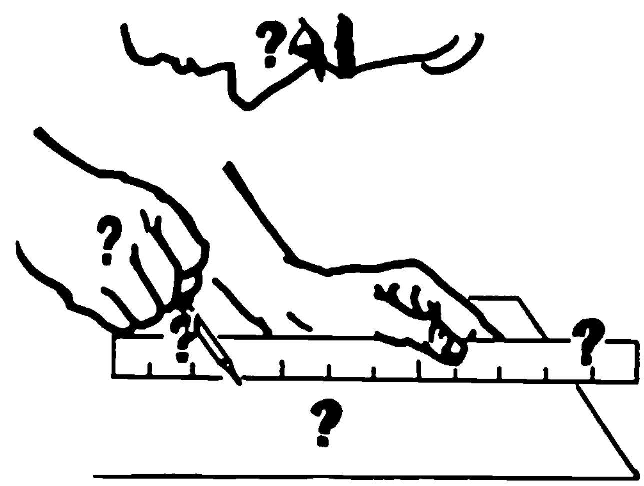


Fig. 27-10. Measurement differences may be due to the part, the measuring instrument, or the inspector.

Destructive Testing

Destructive testing means that the product is destroyed while it is being tested. For example, an automobile tire is wear-tested (worn out) to see how long it will last, Fig. 27-11. Of course, a piece that is destructively tested will no longer be acceptable.

Fig. 27-11. This part is destroyed by a destructive strength test.

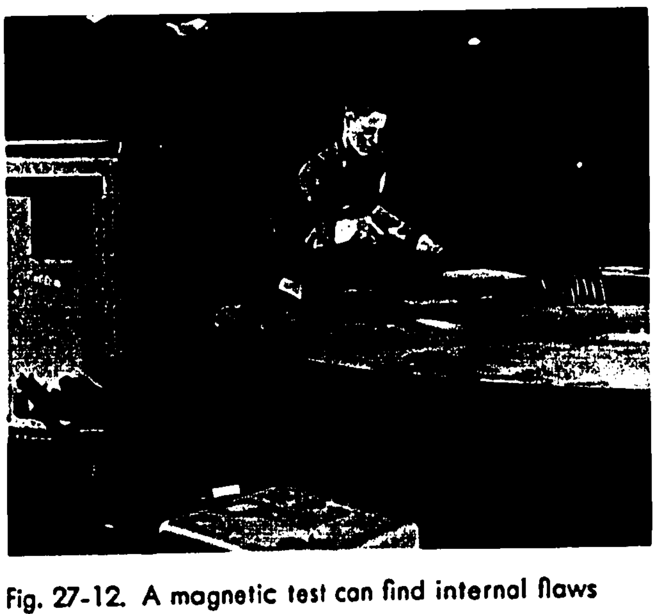


Fig. 27-12. A magnetic test can find internal flaws (defects) without destroying the part.

Nondestructive Testing

In *nondestructive testing*, the product is not destroyed in the process of inspection. Items are acceptable within limits stated in the specifications. The limits are controlled by many different gages and devices. Some of these gages test size, shape, surface smoothness, and hole alignment. Other devices test the *internal* (inside) structure of the material, Fig. 27-12. Metal can be X-rayed for air pockets or cracks. There are also gages for measuring flatness or roundness and gages for testing the operation of the product.

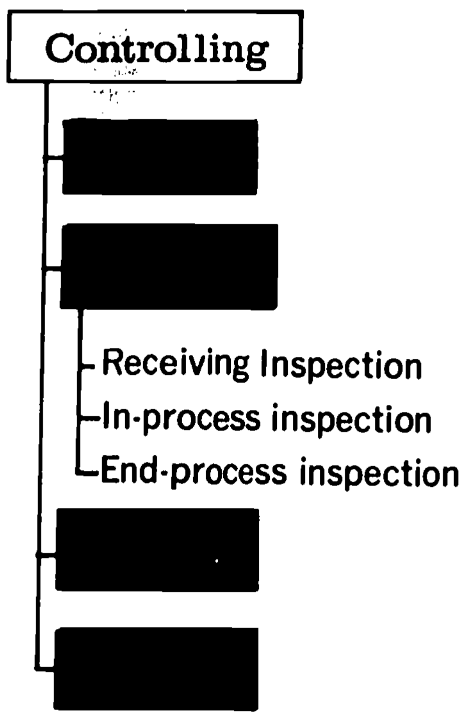
Summary

Quality control only controls a product's quality indirectly. It measures the product against standards and reports the results. The production department is the direct controller and producer of product quality. Inspection reports help in monitoring product quality and in taking corrective action. Control of quality includes monitoring (inspecting), reporting, and correcting.

Process (nonfabricated) products must be controlled for their color, taste, odor, hardness, fluidity, viscosity, and other features. Many chemical and physical tests are used to see if the product is being made according to formula or plan.

Specifications for fabricated products must be checked for four conditions: size, form or shape, positional relationship, and assembly and function. Quality control gages check the first three conditions while the product is being manufactured. Assembly inspections take place after the product is made.

Quality control systems make sure that interchangeable parts are produced for fabricated products. By sampling, inspectors can judge the quality of the parts without checking them all. Inspection and testing can be done by destructive testing or nondestructive testing.



Terms to Know

competitors
quality control
control loop
  a. monitoring
  b. reporting
  c. correcting
inspecting
  a. receiving
  b. in-process
  c. end-process
substandard
analog computer
acceptable quality
standards
fabricated products
process products
nonfabricated products
specifications
size
shape
positional relationship
assembly and function
identical
interchangeable
interchangeability of parts
accurately
at random
variations
abrasion
sampling
defective
destructive testing
nondestructive testing

Think About It!

1. What kinds of products would be tested by *destructive testing*? What kinds by *nondestructive testing*?
2. When many thousands of parts are made by mass production, why is it not necessary to inspect each individual part as it comes off the production line? What would happen if it *were* necessary?

Designing and Engineering the Plant

READING 28

At some time all manufacturers get new or additional plant facilities. This can be done in three ways:

1. They can buy or lease a plant already on the present location or on a new *site* (location).
2. They can build an addition to the present manufacturing plant.
3. They can construct an entirely new plant at the present location or at a new site.

There are several reasons why new facilities may be needed.

1. A new product or a new product line needs a new kind of space.
2. The lease on the present plant ends.
3. The present structure is very old or *condemned* (declared unsafe).
4. The source of raw materials or supplies has changed.
5. Customer location has changed.
6. Tax rates or labor conditions have changed.

Fig. 28-1. Automobile assembly plants are located across the country to be close to their customers.

Site Factors to Consider

There are two very important things to think about in choosing a site. They are the *location of the customers* and the *source of the raw materials*. Usually it costs more to ship finished products than to ship raw materials, so companies like to be near their customers. The automobile assembly plants located across the country are good examples of this, Figs. 28-1 and 28-2. On the other hand, bulky iron ore is changed to steel near the source of coal and the iron ore. A survey of companies that moved showed less than 10 percent moved closer to their source of raw material.

Fig. 28-2. Automotive subassembly plants are located in important places in the country. This is a typical automotive wiring harness assembly line.

The location and rates of *transportation systems* (railroads, trucking lines, airlines, and barges) must be studied. The transportation costs of the company must be as low as possible. Perishable products, like food, are special transportation problems. About one-half of all companies that move list transportation as one of the three most important costs to think about, Figs. 28-3 and 28-4.

Labor is another important cost in locating an industry, Fig. 28-5. Much more than half of the cost of most products is made up of *labor costs*. This is true when all hourly and salaried workers are included in the total cost of labor. To run a plant, a company needs unskilled, semiskilled, skilled, engineering, office, and supervisory workers. A "rule of thumb" is that a company should hire less than 5 percent of the local population or less than 20 percent of the local work force.

Power (energy) is needed in any industry. Present and future needs must be figured. Costs must be figured, based on these needs. For great amounts of expensive power, it may be necessary to locate near a main source of power.

Having plenty of water is also important. Water is needed for personal use, washing, cooling, moving waste, as a *solvent* (to dissolve another substance), and for many other needs. Some plants need much more

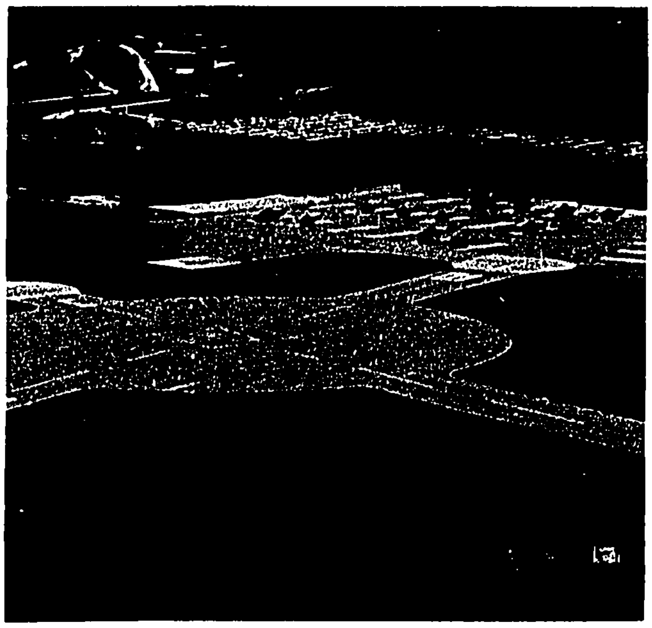


Fig. 28-4. This modern plant has an excellent location. It is close to an expressway, a waterway, and an airfield.

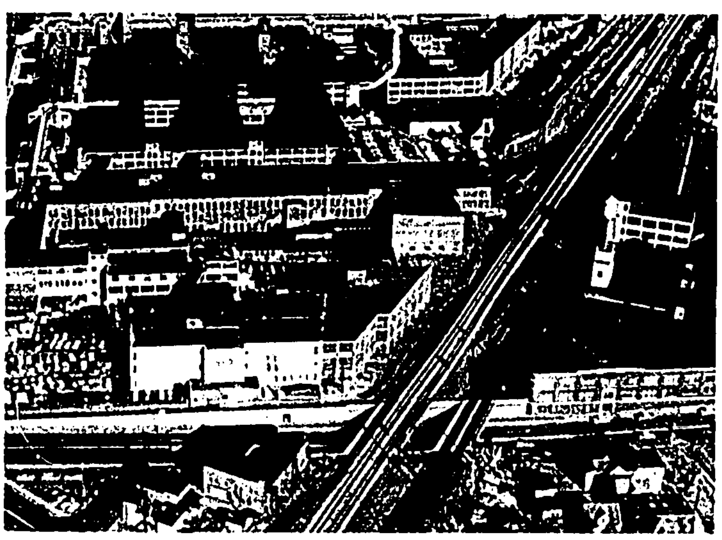


Fig. 28-3. Railroads and good expressways for trucks are important for moving materials and products. Here a number of spur tracks lead to different plants.

Fig. 28-5. Labor is an important cost to think about when a site for an industry is chosen.

water than others. For example, papermaking uses laıge amounts of water for processing. Water towers are put up by many companies to make sure there is enough water, Fig. 28-6.

The climate is also important. Often *extremes in climate* (very hot summers and very cold winters) mean high labor costs and low production efficiency.

In recent years, state and local governments have influenced the location of many firms. *Tax* ·*ates* are very important. Some states have property tax *exemptions* (excused from payment) to attract new industries. Some state and local governments give financial help. The company may need to get operating capital. For this, local sources of money (*financing*) can be very helpful.

Many firms want to locate near universities, colleges, business schools, and research companies. This is important to think about in choosing a site.

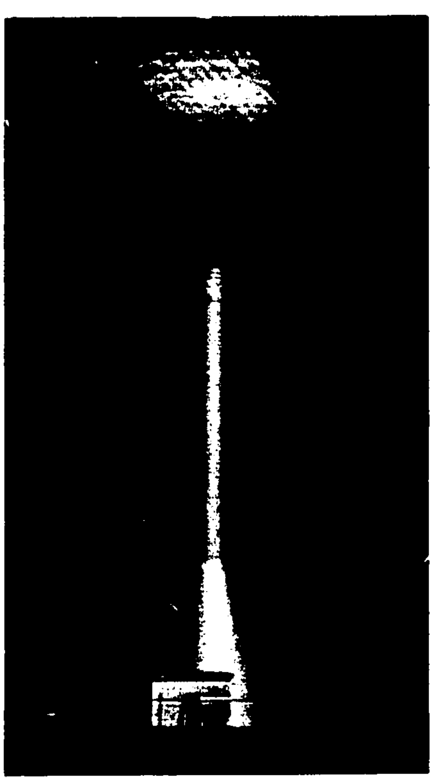


Fig. 28-6. Water towers are constructed by many companies. This rıakes sure there is enough water for manufacturing, fire control, and other emergency uses.

Many other things like cost of land, room for growing (Fig. 28-7), *zoning regulations* (laws on where industries may locate), and *topography* (land features) must be thought about. Still others include nearness to schools, homes, churches, and stores.

Planning the Plant

The first job in building a new plant is to choose the plant designers. The designing may be done by company engineers. It may be done by an outside engineering consulting firm hired for that purpose. A *feasibility study* must be made. Many of the same things you have just read about must be studied.

The plant designers study the product. Does the product always change? Does the company manufacture the same product year after year? Should the product be made in a single-story or multi-story building? Heavy equipment, for instance, should

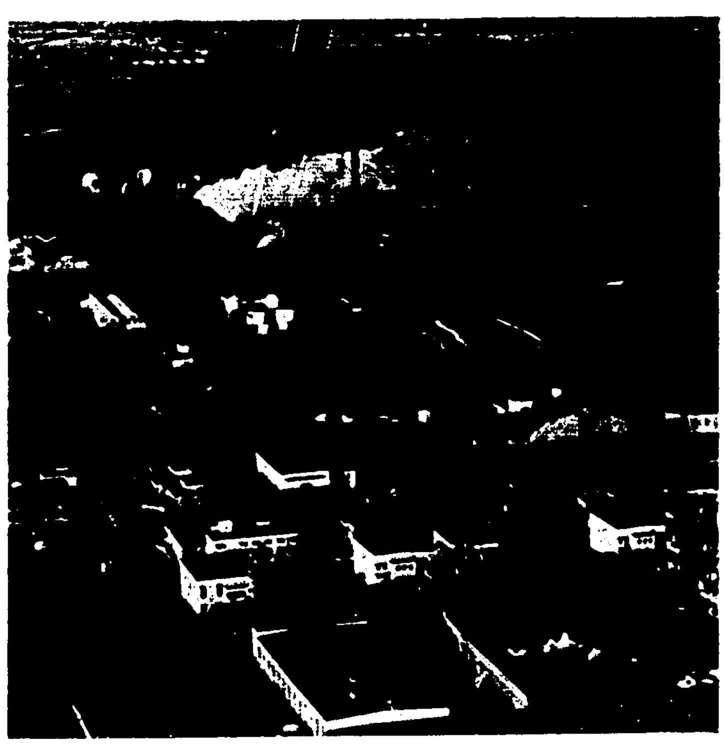


Fig. 28-7. There is enough space around this plant for adding more buildings.

not be used above the first floor, Fig. 28-8. Does the company *convert* (change) raw materials? Does it buy parts (*components*) for assembly? Does it make a number of different products?

Answers to these questions will help decide what kind of structure is needed. Suppose the designers have decided what kind of plant will house the company's product. Then, a grouping by department is made. Suppose, however, that the manufacturer makes more than one product. Then, the designers might place each *product* in one area and call it a *department*. For example, all the machining, painting, and assembling for one product would be done in that one department.

The plant's product might be better made by grouping *processes* into departments. Then there could be a foundry department, a grinding department, a drilling department, a painting department, and an assembly department, Fig. 28-9.

Preparing Plant Layout Drawings

Suppose the grouping by product or by process has been done. The designers now make *preliminary* (beginning) drawings of the plant layout. To do this, they must know present and future production *volume* (number of products made). They must know how automated and specialized the operations will be. Designers must also think about the need for changes due to *obsolescence* (out-of-date) of the product or process.

The designers should now be able to figure out how much total floor space is needed to make the company's product. They use a *flowchart* to help in figuring and arranging this floor space. A flowchart shows all the processes, transportation, inspections, storage, and delays as a product moves through a plant.

The designers' next step is to make a floor plan. They use a special paper with guidelines printed to *scale*, Fig. 28-10. The usual scale is 1/8" or 1/4" to the foot. One sheet can picture the entire floor area of the plant or of only one department. Permanent and temporary walls are shown on the drawing. In fact, anything that is located in the plant will be shown on the plant layout.

To develop the floor plan, designers and engineers may use *templates*. A template is a flat pattern that shows the outline of a piece of equipment. The templates are made

Fig. 28-8. This 16,000,000-pound forging press needs a solid floor to rest on and a high ceiling for clearance.

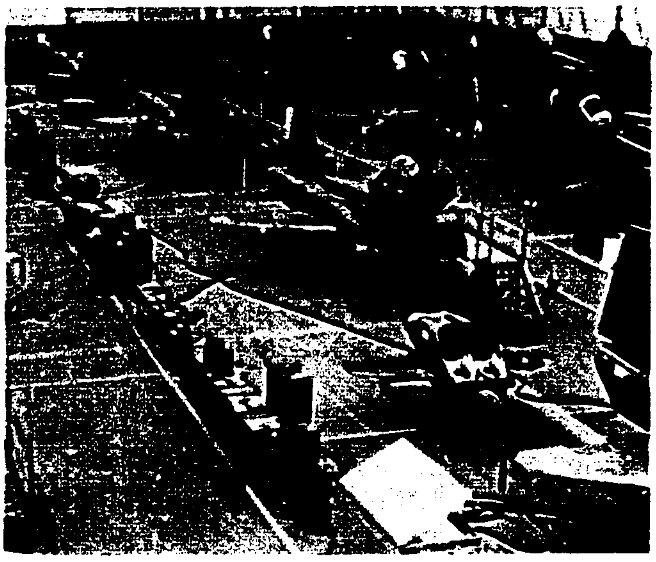


Fig. 28-9. Plants are sometimes divided into process areas. This department is where wings, fuselage, and engines are put together.

to the same scale as the floor plan. They are moved about on the floor plan until the best layout is found. Aisles, offices, workbenches, any every detail of the plant are shown on the layout.

A more expensive way to show the layout is to use models, Fig. 28-11. These are small three-dimensional models of equipment and tools. They are made in scale form (1/8" to the foot or 1/4" to the foot). Like templates, they also can be moved around on the layout plan.

Fig. 28-10. This is a floor plan of an iron foundry drawn on special paper. Each foot equals 1/8" on the plan.

Fig. 28-11. Three-dimensional models are sometimes used to help design plant layouts.

Advantages of Good Plant Layout

If the planning is done well, a good plant layout can help in several ways.

1. It can make an economical use of floor space.
2. It can reduce cost of equipment.
3. It can reduce handling of materials and parts.
4. It can increase the use of men and machines.
5. It can make sure of safe and comfortable working conditions.

Good planning will reduce production costs and increase profits.

Summary

There are many things to think about when an addition to a plant or a new plant is planned. Location is very important. Plants should be close to raw materials, to customers, to workers, to power, and to water.

In designing a new plant, the product to be made and the processes to be used are carefully studied. Drawings and plant layouts help designers and engineers develop the plans for the new plant.

Terms to Know

site	feasibility study
condemned	convert
transportation systems	components
labor costs	preliminary
power	volume
solvent	obsolescence
climate extremes	flowchart
tax rates	scale
exemptions	templates
financing	models
zoning regulations	
topography	

Think About It!

1. What kinds of transportation problems must be solved by automobile manufacturers? by manufacturers of dairy products? How are the problems and solutions different?
2. Why is the availability of schools, homes, churches, and recreation areas important for a company to think about in choosing a good location?

Designing and Engineering the Plant

- Recognize need
- Gather data
- Evaluate data

- Develop ideas
- Make sketches
- Write ideas
- Record thoughts

- Select better prelim. ideas
- Make scale drawings
- Determine lengths, sizes, & shapes

- Site analysis
- Functional analysis
- Structural analysis
- Cost analysis

- Prepare graphs, charts, diagrams, schematics
- Present to the group
- Decide – acceptance or rejection

- Prepare working drawings & specifications
- Construct the manufacturing plant

Establishing Accident Prevention Programs

READING 29

The problem of industrial health and safety is a complex one. It ranges from minor accidents and fatal injuries to occupational diseases.

In this reading it can only be described in general terms, with emphasis on prevention programs.

Progress in Safety Activities

In the past fifty years, manufacturers have made some progress in safety, Fig. 29-1. There was almost a complete lack of safety efforts 50 years ago. Since 1930 the rate of serious accidents in industry has gone down nearly 50 percent.

But people are still being killed in work accidents that could have been prevented. Work accidents that cause loss of eyes, hands, and other parts of the body also occur far more often than they should. Many workers suffer from diseases contracted while working in an unfit environment or around dangerous chemicals.

Many large employers (1,000 or more workers) have *accident prevention programs*. But many smaller employers have no programs. See Fig. 29-2. A common phrase or slogan that grew out of work places where all are concerned with human life is that "safety is everyone's business." This means that everyone (managers, foremen, union representatives, workers, and government) must be concerned with safety in order to save human lives and prevent suffering. Only then will real progress be made toward making the work place a safe place.

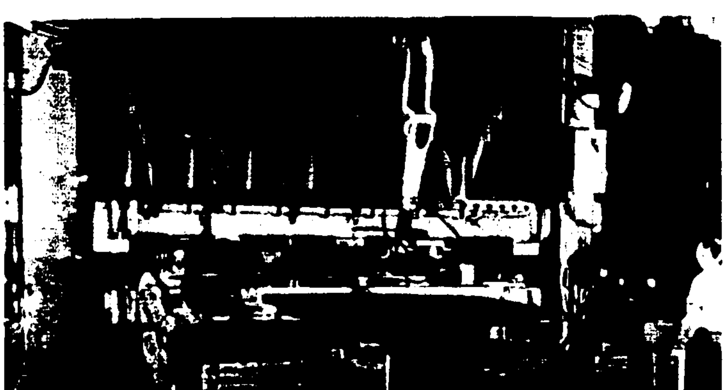


Fig. 29-1. Sheet metal is cut to size on this 300-ton press which has special safety controls. Each operator must press two individual buttons at the same time before the press will operate.

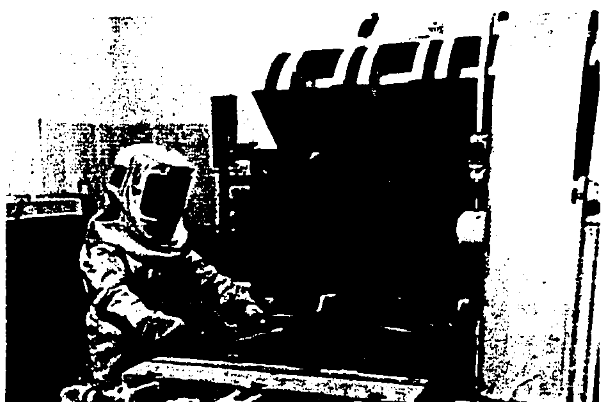


Fig. 29-2. The worker in this picture is joining two metals together by the use of heat and pressure at controlled times in a controlled atmosphere. He is wearing a fireproof pressurized suit for safety.

History of Accident Prevention

Industrial safety efforts grew slowly. As early as 1906, big steel firms began to study work *hazards* (dangers). There were very few studies of this kind at that time.

In addition to the pain and agony of industrial accidents or disease, there is a loss of work and hence a loss of income that the injured worker experiences. Before *workmen's compensation* laws were passed by states (around 1911), the injured worker was at the mercy of the employer or dependent upon charity. He was not able to go into court and sue because the law said that the employee in agreeing to work had assumed the risk of whatever might happen to him. Basically, workmen's compensation laws, even though they differ from state to state, eliminate any idea of fault. It does not matter who is to blame if the employee is injured in the course of his employment. He is *compensated* (paid) for a portion of his *lost time* (wages) and *medical costs.*

Progress in industrial safety began to spread because workmen's compensation laws said the employer must pay *insurance premiums* (costs) to the state or insurance companies. Some laws also say that with permission a company can be a *self-insurer.* This means the company is able to pay directly to the injured worker without paying premiums.

The larger the accident costs are, the higher the premium that the employer pays. The possibility of reducing their insurance premiums gave employers the first major reason for increased safety efforts. The workmen's compensation laws helped to start the first serious efforts of employers to reduce accident hazards. See Figs. 29-3 and 29-4.

Since 1912, other groups have also helped to speed up safety efforts. The federal government, state governments, insurance companies, the *National Safety Council,* labor unions, and other agencies all join in promoting safety.

The most recent law concerning industrial safety is the *National Occupational Health and Safety Act,* signed into law by the President in December of 1970. Because of

Fig. 29-3. Molten steel is being poured into ingot molds. Note the fireproof coats and safety glasses the employees are using.

Fig. 29-4. An efficient system of dust collection makes it possible for these employees to machine metal in a dust-free area.

the laxity on the part of state laws, the federal government enacted this law to set national health and safety standards that will be administered by the U. S. Department of Labor. One example of a safety standard is a regulation that highly inflammable liquids be stored in bright red containers and clearly labeled with the name of their contents. Another is that protective devices should be used whenever the air is too dirty for the worker to breathe.

Accident Problem-Solving

Today's accident problems happen in all manufacturing plants. They happen regardless of the size of the plants or the kind of product made or manufacturing processes used.

Accident problem-solving begins when there is a difference between what *should be* (a planned course of action) and what *is actually happening* (unsafe conditions or unsafe acts). The next step is to find out what is causing this problem.

Safety is not a separate element of a job. Jobs are made up of men, machines, methods, materials, and minutes. To prevent accidents all parts of a job must be done well. This means working efficiently and safely, Fig. 29-5. Failure to have a planned course of safe action in every part of a job can lead to a worker being injured.

Accident controls in the *mechanics* of the job (machines used) have received some attention. But there has not been enough stress on the *humanics* of the job (people working) or the use of various chemicals and other substances in industrial processes. Failure to plan safety into all parts of a job is a large part of today's problem. See Fig. 29-6.

Basic Principles of Accident Problem-Solving

The job of preventing accidents especially needs the cooperation of plant foremen, men who are in charge of the work place. The foreman needs the cooperation of all who

Fig. 29-5. These employees are handling a large engine with an electric hoist. Would it be safe to try to lift the engine without the hoist?

Fig. 29-6. An ingot of steel is being squeezed between dies to form a giant shaft. The worker is safely protected from head to foot in fireproof clothing while he is removing scale formations from the steel.

are working in the area and of those who plan the processes for the area.

Foremen must see to it that there are *safeguards* (protections) for jobs. They must try to develop safe attitudes in their workers. A necessary first step in starting an accident prevention program is setting up an accident prevention organization. These organized efforts must get and keep the cooperation of all *supervisory employees* (persons in charge).

Safety programs should be under the direction of someone who can *coordinate* them. He must make sure that everyone's safety efforts work together. The number of people who coordinate safety programs is increasing.

In many plants where labor unions exist, there are *labor-management safety committees*. These committees, made up of supervisors, union representatives, and workers, join together to insure that safety standards are met.

How well a plant's safety program will reduce accidents depends on how much interest in the program the safety committee takes. See Fig. 29-7.

Procedures for Carrying Out Accident Prevention Programs

To make safety a habit, a planned course of safe action must be part of every job. Regular safety inspections need to be made to see if safety standards are being practiced, Fig. 29-8. *Inspectors* should also *investigate* (study carefully) the causes of all accidents. Changes are then made so that accidents can be prevented in the future.

The foreman and safety committee members should teach the workers about safe methods. They should stop any unsafe acts. They should also study new and changed jobs for dangerous working conditions.

To protect the employee there are many kinds of safety equipment. Some examples are fire extinguishers, safety glasses, goggles, face shields, safety shoes, boots, gloves, hard hats, *respirators* (to prevent breathing-in harmful substances), masks, and aprons. See Figs. 29-9 and 29-10. But it should be remembered that these devices do not remove the hazards. They merely protect the workers from them.

Fig. 29-7. Remote control hands behind this protective enclosure are used by the technician to handle dangerous Cobalt 60.

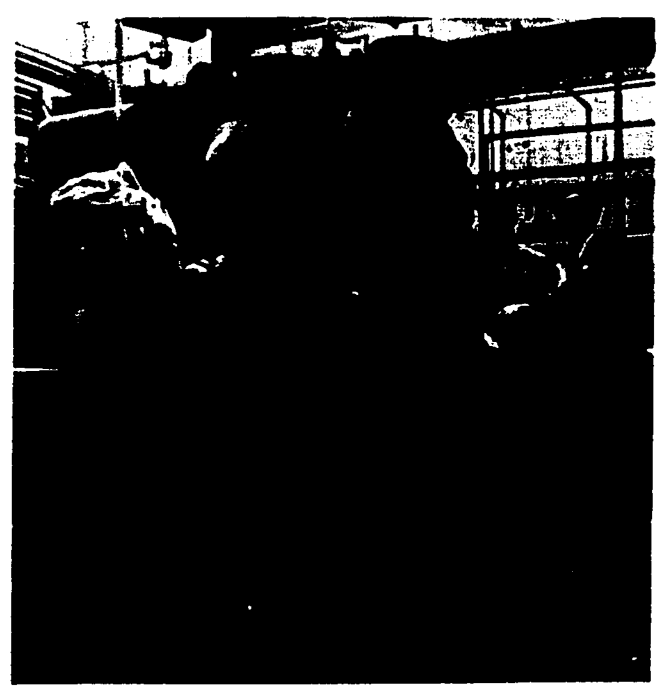


Fig. 29-8. A safety inspector supervises the correct operation of a machine.

Careers in Safety

More and more plant managers are learning that a good safety program is worth having. It reduces costs, raises profits, increases production, increases employee *morale* (good work attitudes), and brings job security to everyone, Fig. 29-11. Thus there are many jobs today in industrial safety. All big companies now have safety directors who supervise safety personnel at each plant. Safety inspectors are employed by all large companies, Fig. 29-8. Labor unions cooperate with companies to improve safety. Many union representatives on the job are trained in safety programs.

The state and federal governments, because of laws such as the one stated earlier, are hiring more safety inspectors to insure that *uniform standards of safety* are being maintained.

Universities are adding safety engineering courses to their study programs, Fig. 29-12. Jobs in industrial safety are increasing.

Fig. 29-9. Here a worker is adding chemicals to a mixing vat. He is wearing a respirator, safety glasses, and a hard hat to protect himself.

Fig. 29-11. A good worker always performs his job safely, as this worker is doing.

Fig. 29-10. A worker is sandblasting a metal casting. He is protected from the flying sand by special clothing.

Fig. 29-12. Dummies are used to imitate dangerous situations in safety engineering courses at colleges and universities.

Problems of *industrial health,* like air and water pollution, are of great concern to many people. *Ecology* (study of living things in rela.'on to their environment) will no doubt have more effect on industrial processes in the future.

Summary

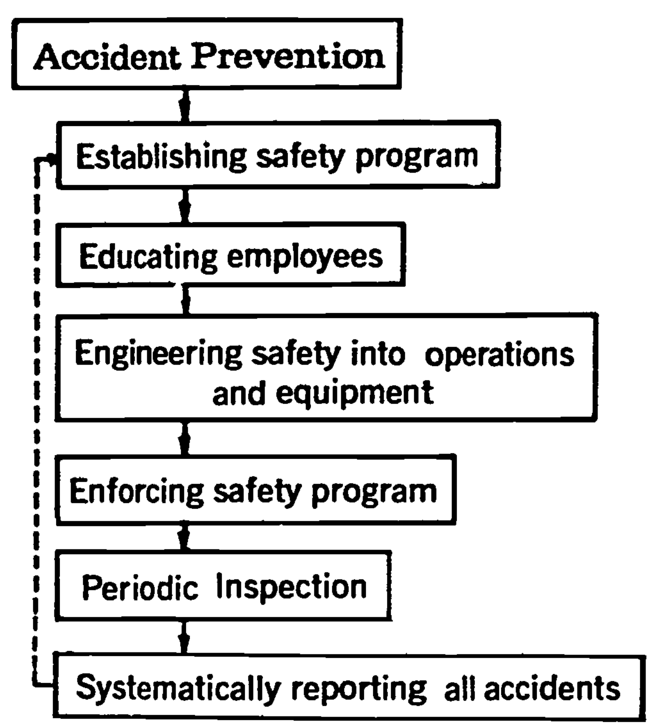
Fifty years ago there was almost no planned, organized effort to make workers safe on their jobs. In 1912, workmen's compensation laws were passed. These laws made employers pay for medical care and other aid for workers injured on the job. When the cost of accidents in a plant is high, the employer pays high insurance premiums. Workmen's compensation laws made employers aware of the high cost of accidents. They began to plan and organize safety programs. The federal government has taken steps to insure safety standards in all industries.

A program to prevent accidents must involve the physical plant, materials, machines, methods, and all employees, Fig. 29-13. Management personnel and plant foremen are in charge of safety programs. But safety is everyone's business; anyone can have an accident on the job. The *humanics* of safety needs more research. More study is also needed as to the causes of *industrial diseases.*

Fig. 29-13. Note the clean, well lighted, safe working conditions of this electronics assembly plant.

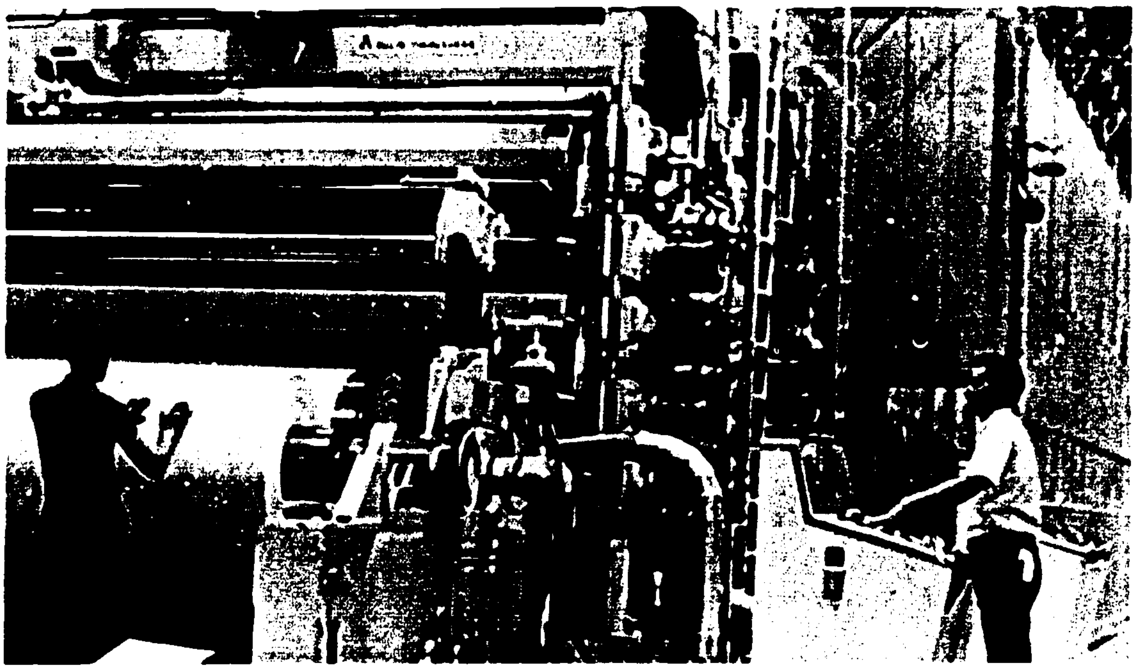
Terms to Know

accident prevention programs
hazards
workmen's compensation
compensated
lost time
medical costs
insurance premiums
self-insurer
National Safety Council
National Occupational Health and Safety Act
mechanics
humanics
safeguards
supervisory employees
coordinate
labor-management safety committees
inspectors
investigate
respirators
morale
uniform standards of safety
industrial diseases
industrial health
ecology



Think About It!

1. Why do you think that it is true that the larger the company, the more likely it is that the company will be interested in promoting occupational health and safety programs for its workers?
2. Why is it easier to plan accident controls for machines than it is for people?



READING 30

Supplying Equipment and Materials

In this reading you will learn about getting equipment and materials for a production system. You will learn why equipment and materials are needed, what equipment and materials are *purchased* (bought), why and how they are bought, and who does the buying.

Equipment

Production is a *conversion* (changing) process. Inputs of materials are *converted* (changed) into useful products. Equipment is usually needed to help men produce these products, Fig. 30-1. This equipment consists of machines, additional tooling and equipment, and other items. All of these are used directly in working, treating, inspecting, or packaging the product. Ovens, molding machines, lathes, drill presses, punch presses, milling machines, pressure cookers, conveyors, fork-lift tractors, gages, hand tools, and workbenches are pieces of equipment needed for some kinds of production.

Equipment Selection

Choosing the right equipment is important. Industrial competition has made the unit manufacturing cost an important measure of *operating success*, Fig. 30-2. Operating success is the making of a product at a cost that will bring a profit when the product is sold. Equipment is chosen by studying *technical requirements* (needs) and *economic* (cost) *factors*, Fig. 30-3.

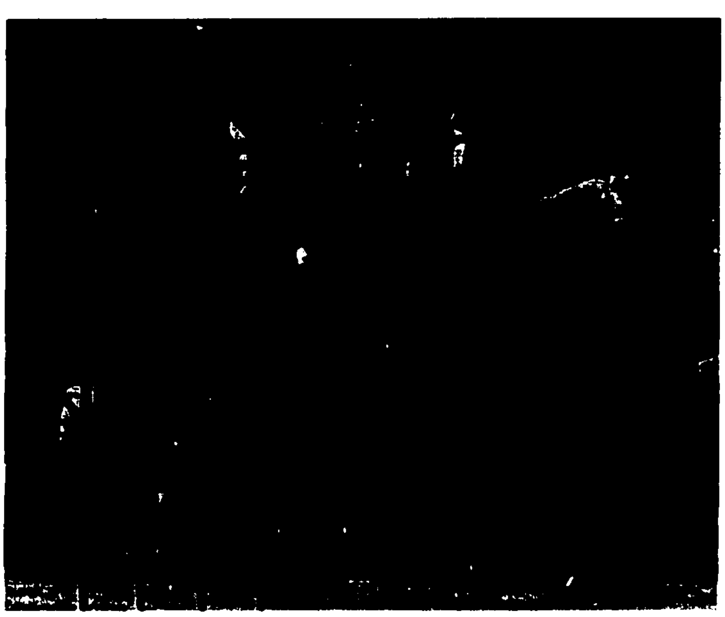


Fig. 30-1. Equipment can cost many thousands of dollars for each employee.

Fig. 30-2. This machine has an equipment cost of $6,000 and a production rate of only a very few parts an hour.

Technical Requirements

An important question to ask about equipment is: Can this equipment do the job? Many different kinds of equipment might be used to make the product. Other technical factors must be thought of. The *rate of production* (how many parts *must* be made in an hour) is compared with the *cycle time* (how many parts *can* be made in a hour) of the machine. Suppose that management knows the total number of pieces the equipment will have to make. They can then figure out how long the equipment will last. The better the product to be sold, the more accurate the equipment must be.

There are other technical factors to be thought of. How skilled must the operator be, Fig. 30-4? How safe is the equipment? What is the scrap rate of the equipment? What will the setup time for the process be? What maintenance will be needed? How dependable is the equipment?

Equipment that needs highly skilled operators will have high labor costs. Also, there are often fewer skilled workers than are needed. Safety is important today. Most states have strict laws about the safe use of industrial equipment. Industrial accidents cause the company to lose money because of lost production and worker *compensation* (pay) for injuries.

Fig. 30-3. This battery of eight spindle lathes has an equipment cost of $90,000 and a production rate of 80 parts per hour.

As material costs increase, loss due to scrap becomes more important. A lot of *down time* (time when machines are shut down) for setup or breakdowns cuts down production and increases costs, Fig. 30-5.

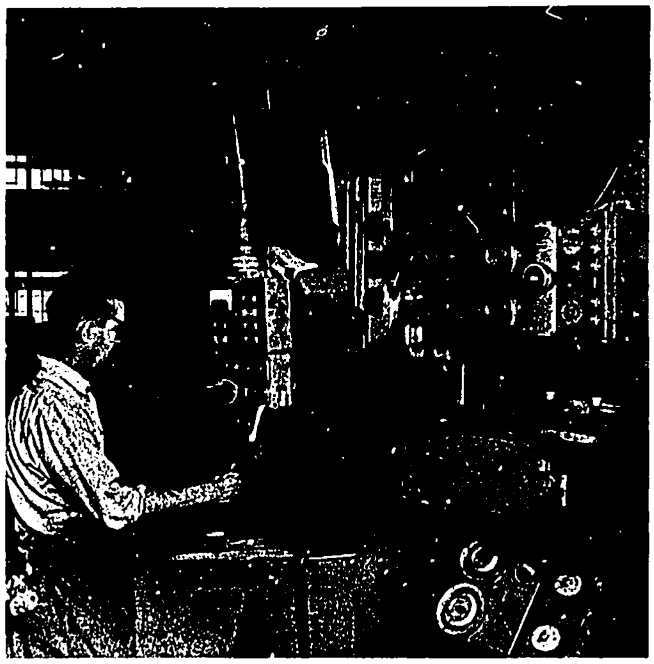


Fig. 30-4. The skill the operator needs may help decide the choice of equipment.

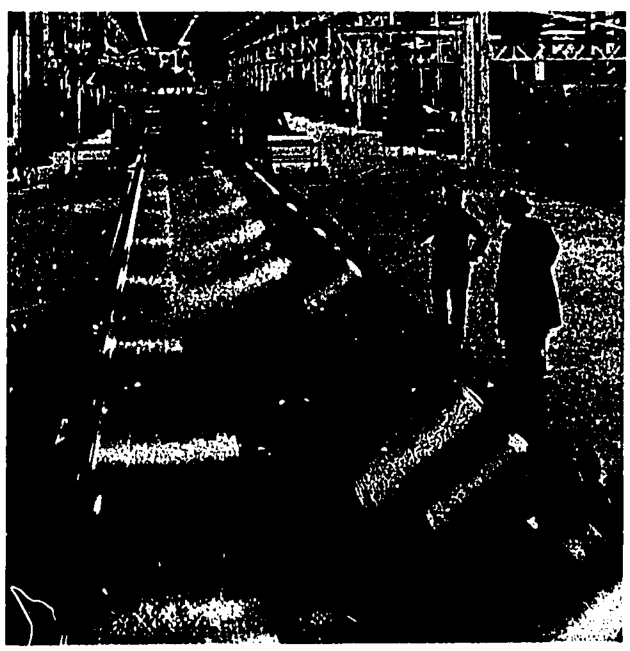


Fig. 30-5. A breakdown of this glassmaking machine may shut down the entire plant.

Improvements in industrial technology have brought about many new cost-saving machines. Some machines *transfer* (pass) material from one processing machine to another without human help. Some machines are programmed to run through *complex* (complicated) machining cycles. Other machines inspect their own output and correct their own setting when necessary. All of these factors must be thought of when choosing the right equipment to use.

Economic Factors

Important economic (cost) factors must be thought of in choosing the right equipment. These are the cost of using the equipment, the cost of buying it, and its total cost to the company. High speed, *special purpose equipment* usually costs less to run than *general purpose equipment.* But special purpose equipment costs more to buy than general purpose equipment. The cost of buying and using the equipment is added to the total costs of the plant. So, management must think about total costs in choosing the right equipment.

Management Decisions

Management has complete knowledge of the company and its needs. Management must also make sure the company makes a profit. To this end, it must make many decisions. Some decisions concern the use of the best technical equipment which often is very expensive.

Management must decide whether to make, buy, or *lease* (rent) the equipment, Fig. 30-6. This decision is based on costs and the technical abilities of the company and its *vendors* (sellers of the product). Also, *security* may be important. Suppose management does not want other companies to learn what processes will be used. Then the company may have to make its own equipment.

Materials

Production is a conversion (changing) process. It changes inputs of materials into useful products. The materials may be raw materials, industrial materials, or component parts. Iron ore, bauxite, sugar beets and wheat are examples of *raw materials.* Steel, aluminum, refined sugar, and flour are examples of *industrial materials.* Nuts, bolts, switches, transistors, and special manufactured parts are examples of *component parts.*

Management must decide which form of materials to buy, Fig. 30-7. Some manufacturers produce industrial materials from raw materials. Other manufacturers process industrial materials into component parts to be used by still other manufacturers. Some companies produce *end* (finished) *products* from industrial materials and component parts.

Fig. 30-6. Decisions about equipment purchases must be made by management.

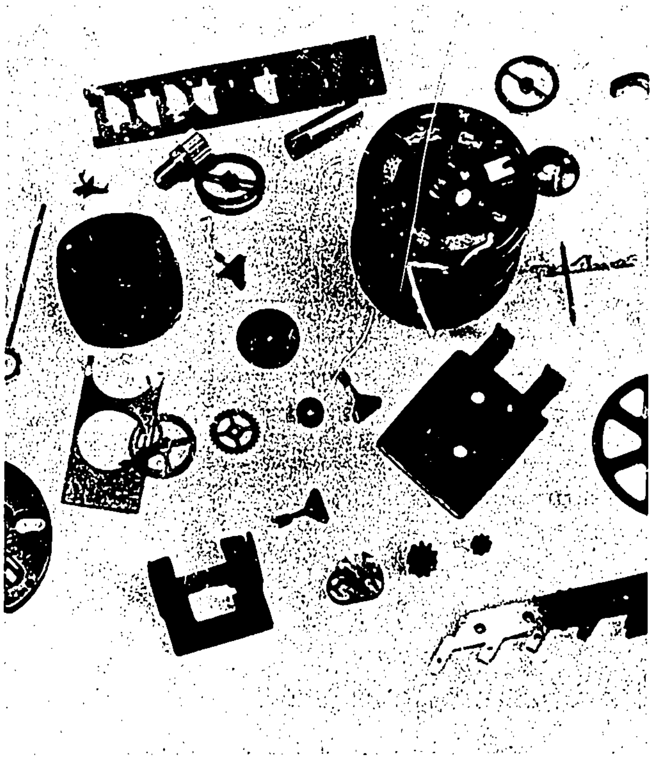


Fig. 30-7. Decisions must be made as to which parts a company will *make* and which parts it will *buy*.

Procurement

Procurement (obtaining) is getting materials and parts needed by the production group. The right *material* of the right *quality* must be bought from the *most economical* (cheapest) *source*. This material must be supplied, delivered, or received in the right *quantities* to the right *place* at the right *time*.

Usually, the purchasing department chooses sources of supply, *negotiates* (makes arrangements) with suppliers, orders materials, and follows up delivery promises, Fig. 30-8. In small firms, the purchasing department may be one man, the *purchasing agent*. In larger firms, the purchasing department may be headed by a vice-president of procurement. Working for him may be several purchasing agents, senior *commodity buyers* (material or product buyers), junior buyers, *expediters* (persons who assist in obtaining materials or products on schedule), and a large office staff.

Responsibilities of a Typical Purchasing Department

Primary Duties	Secondary Duties	Optional Duties*
a. Develop list of potential vendors or suppliers	a. Decide whether to make or buy certain items	a. Traffic
b. Interview suppliers' salesmen	b. Purchase capital equipment and construction items	b. Salvage
c. Investigate suppliers' plants, capabilities, and reputation	c. Maintain inventory control	c. Inspection
d. Secure quotations (bids) and negotiate terms	d. Purchase outside research services	d. Stores
e. Select the supplier and award the contract	e. Prepare reports to management	
f. Handle adjustments and rejections		
g. Schedule purchases and deliveries		
h. Sell scrap, surplus, obsolete items		
i. Check legal aspects of contracts		

*These may or may not be purchasing department duties.

Fig. 30-8. The usual jobs of a *purchasing department* are listed in this chart.

REQUEST FOR MATERIAL

DATE April 1, 1971

No 9711-171

ORDER FROM: Suggested Vendors:

X Machinery Co.

Y Machinery Co.

Z Machinery Co.

Material Needed: ☐ IMMEDIATELY, PHONE ORDER ☐ NORMAL DELIVERY ☐ BY: Sept. 1, 1971 (Date)

QUANTITY	ITEM	FOR: Job Description or Department	EST. COST
1	Offset printing press	printing plant	$49,000.00
	2-color, 19" x 25" sheet size,		
	Sheetfed, automatic side for gripper		
	operation. GRAPHIC No. 125 or		
	equivalent.		
	Price to include installation		

Requisitioned By B. J. King Approved By [signature]

Fig. 30-9. The *purchasing procedure* starts with a requisition.

McKNIGHT & McKNIGHT PUBLISHING COMPANY

ZIP CODE 61701 AREA CODE 309

BLOOMINGTON, ILLINOIS • TELEPHONE 663-1341

April 15, 1971

To: X Machinery Company
Zebra Street
Cincinnati, Ohio

Quote on this sheet your net price F.O.B. McKnight Publishing Company, Bloomington, Illinois, for the items specified below. We reserve the right to accept or reject all or part of this proposal.

Quotations received until 4:00 p.m. 5-15-71

QUANTITY	REQUEST FOR QUOTATION--This is NOT an order	Unit Price	Total
1	Offset printing press -- 2-color, 19" x 25" sheet size. Sheet fed, automatic side guide for gripper operation. GRAPHIC No. 125 or equivalent Installation included. The model, or catalog numbers used on the above inquiry are for your identification of the item. Acceptable alternates will be considered on all items, but if your offer differs from the material requested, complete description must be submitted. Please sign and return original and one copy.		$48,750.00

TO MANAGER OF PURCHASES, McKNIGHT & McKNIGHT PUBLISHING COMPANY

WE QUOTE YOU F.O.B. McKNIGHT PUBLISHING COMPANY DELIVERY CAN BE MADE Sept 1, 1971

X Machinery Company CASH DISCOUNT TERMS Net 30 days
(Sign Firm Name Here)

May 1, 1971 Per S.M. Faulk
(Date)

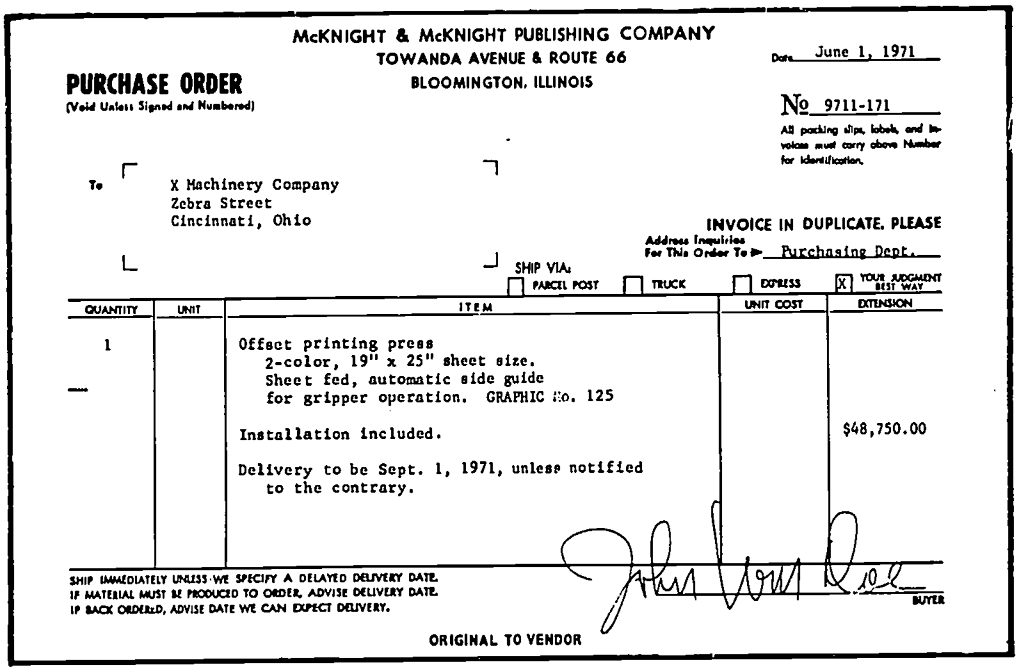
Fig. 30-10. Potential vendors submit bids offering to supply the equipment at a fixed price.

Purchasing Procedure

Procurement starts with a *purchase requisition,* Fig. 30-9. This is an order from management to buy the items listed. The requisition states the exact specifications for each item, the quantities needed, and the date needed. Purchasing personnel study the requisition. They may suggest different materials, different quantities, or another delivery date. They must use the money for the purchase to the best advantage. Management must decide whether or not to accept the suggestions of the purchasing department.

Purchasing agents may choose *potential* (possible) suppliers from the vendors who already sell to the firm. They may use a *register* (book) which lists manufacturers by product. The vendors are *screened.* Several acceptable vendors are picked because of their ability to produce; their reputation for quality, service, and delivery; and their reputation for honesty and dependability.

The purchasing department then issues a *request for a bid* (*quotation*) to each of the acceptable suppliers. The request for quotation asks the supplier to *quote a price* (give a fixed price) for the items listed. Specifications of the quantity and quality needed, and delivery dates are included in the request for



McKNIGHT & McKNIGHT PUBLISHING COMPANY
TOWANDA AVENUE & ROUTE 66
BLOOMINGTON, ILLINOIS

PURCHASE ORDER
(Void Unless Signed and Numbered)

Date June 1, 1971

No 9711-171

All packing slips, labels, and invoices must carry above Number for identification.

To X Machinery Company
Zebra Street
Cincinnati, Ohio

INVOICE IN DUPLICATE, PLEASE

Address Inquiries For This Order To ► Purchasing Dept.

SHIP VIA: ☐ PARCEL POST ☐ TRUCK ☐ EXPRESS ☒ YOUR JUDGMENT BEST WAY

QUANTITY	UNIT	ITEM	UNIT COST	EXTENSION
1		Offset printing press 2-color, 19" x 25" sheet size. Sheet fed, automatic side guide for gripper operation. GRAPHIC No. 125		
		Installation included.		$48,750.00
		Delivery to be Sept. 1, 1971, unless notified to the contrary.		

SHIP IMMEDIATELY UNLESS WE SPECIFY A DELAYED DELIVERY DATE.
IF MATERIAL MUST BE PRODUCED TO ORDER, ADVISE DELIVERY DATE.
IF BACK ORDERED, ADVISE DATE WE CAN EXPECT DELIVERY.

BUYER

ORIGINAL TO VENDOR

Fig. 30-11. The purchasing department orders from the best bidder.

item quotation. When the bids (quotations) are returned, the purchasing department studies them for prices, terms, and delivery promises, Fig. 30-10.

Sometimes, purchasing personnel question the prices quoted, the terms, or the delivery promises. They use their knowledge of the market and the cost estimates to *negotiate* (arrange or bargain) for a better contract. As soon as price, delivery, and terms are settled, the purchasing department makes out a *purchase order*. The purchase order *authorizes* (gives permission) to the supplier to produce and ship the materials ordered, Fig. 30-11.

The purchasing job is not finished. The purchase order is followed up to make sure that delivery will meet schedule. Purchasing personnel *expedite* (speed up) delivery when necessary. After the order is delivered, they check the *receiving reports* (records of materials actually received) to be sure that the vendor shipped the right material in the right quantities. The purchasing department also checks the accuracy of the vendor's *invoices* (list of materials, prices, shipping charges, etc.) and approves them for payment.

Methods of Purchasing

Over a period of months, the price of a material may *fluctuate* (rise and fall) several times. In a market with fluctuating prices, the company may save money by a

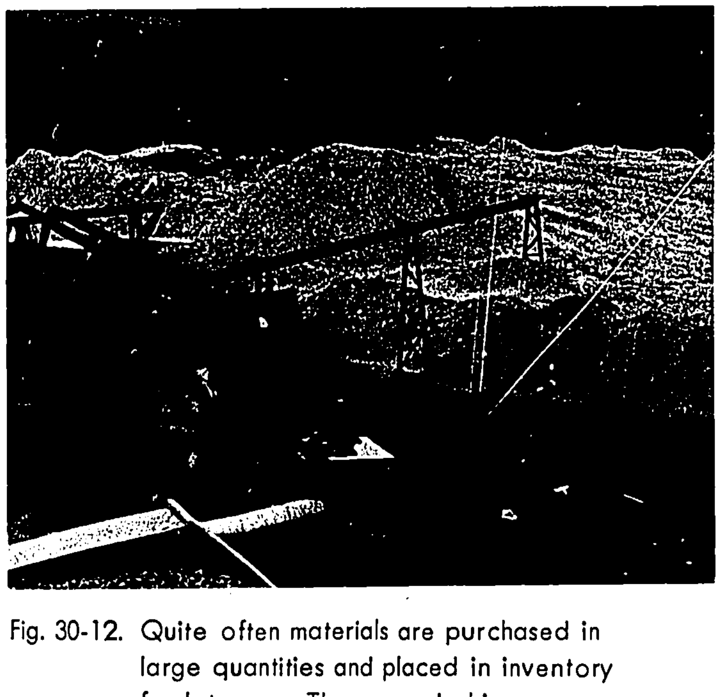


Fig. 30-12. Quite often materials are purchased in large quantities and placed in inventory for later use. These wood chips are stored outdoors.

hedging method of purchases. For example, in a market with falling prices, materials may be purchased "hand-to-mouth." The quantity bought may be just enough to last a few weeks. In a market with rising prices, purchasing agents may buy more than enough materials to meet current needs. Then, the company has a supply of low-cost materials for some time after the market price rises. Sometimes the purchasing department *budgets* the material purchases. This means that the company spends the same *dollar amount* for material every month. When prices are high, the company buys a smaller amount of material. When prices are low, it buys a larger amount, Fig. 30-12.

Authority

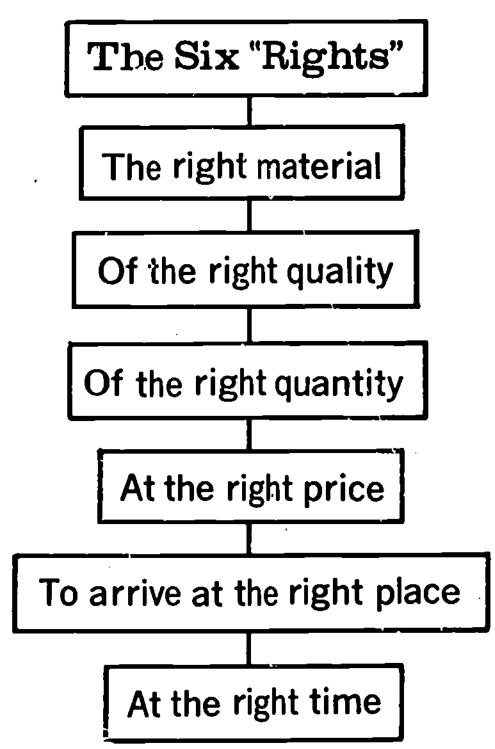
Two kinds of *authority* (approval) are needed for procurement. One is management authority. Management *authorizes* (approves) the purchase of materials so that production can start or continue. The other authority is the purchasing agent. He has the authority to promise vendors that the company will pay for materials ordered. This allows the vendor to accept orders from the company because he knows that the delivered materials will be paid for. The vendor also knows that any shipping costs agreed upon in the contract will be paid for.

Summary

Management must decide what equipment and materials will be used in production. Both technical and economic (cost) factors must be thought of. Much of the equipment and all of the materials may be supplied by outside vendors. Purchasing makes sure that the manufacturer gets what he needs from his suppliers. A company must purchase the six "rights": the right *material,* of the right *quality,* of the right *quantity,* at the right *price,* to arrive at the right *place,* at the right *time.*

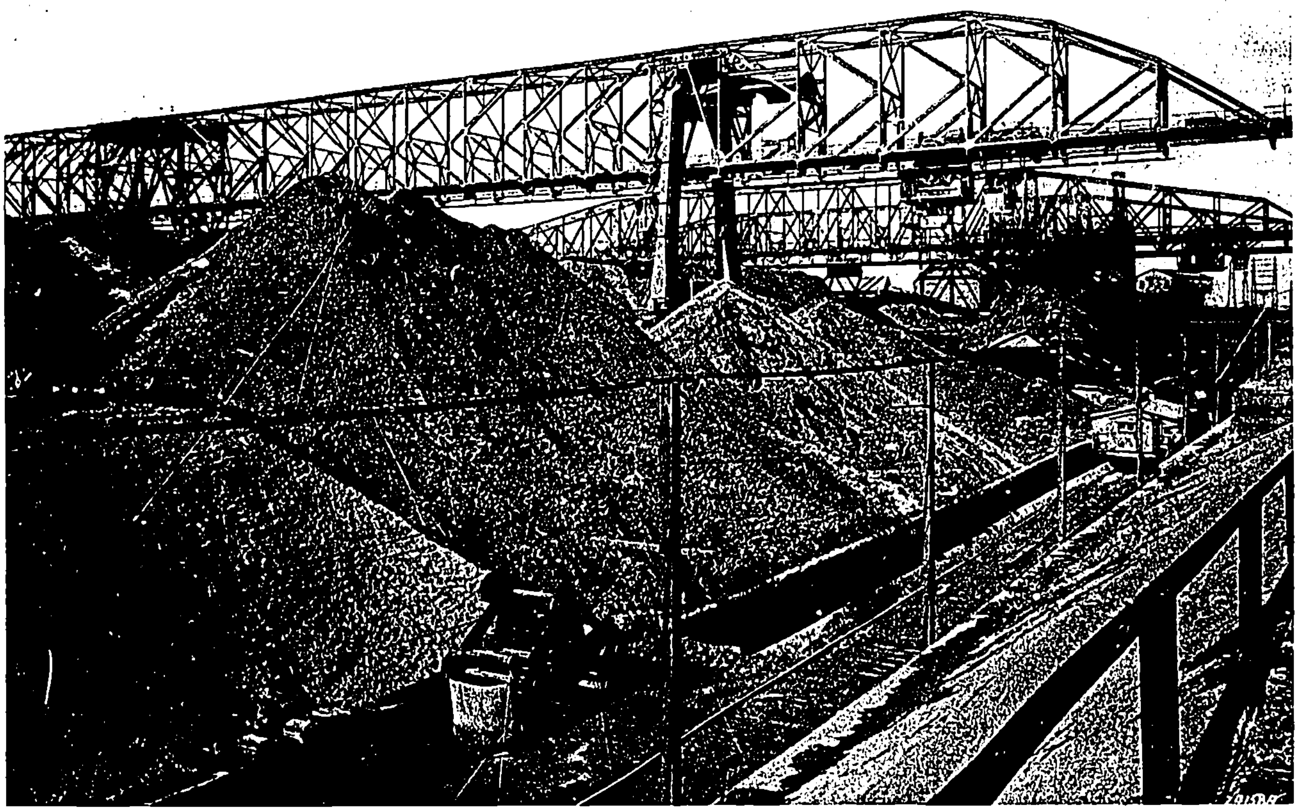
Terms to Know

purchased
conversion
converted
operating success
technical requirements
economic factors
rate of production
cycle time
compensation
down time
transfer
complex
special purpose equipment
general purpose equipment
lease
vendors
security
raw materials
industrial materials
component parts
end products
procurement
economical
source
negotiates
purchasing agent
commodity buyers
expediters
purchasing department
purchasing procedure
purchase requisition
potential
register
screened
request for a bid (quotation)
quote a price
purchase order
authorizes
expedite
receiving reports
invoices
fluctuate
hedging
budgets
dollar amount
authority



Think About It!

1. *Special purpose equipment* costs more to buy than to operate. *General purpose equipment* usually costs more to operate than to buy. How can management decide which kind of equipment to buy?
2. What could happen if a purchasing department did not *screen* its *vendors?*



Processing Data or Information

Any collection of words or figures that have meaning may be called *data* or *information. Data processing* is anything that is done to or with data. In manufacturing, there is a great need for data processing. Manufacturers must keep track of raw and finished materials, time worked by each person, costs of materials, labor, and many other things. All these *data* (information about goods, materials, time, costs, etc.) need *processing* (keeping track of, totaling, calculating, etc.). Years ago this used to be done by hand with a pencil and paper. As manufacturing grew, it became impossible to keep up *manually* (by hand) with the processing of data. Today *data processing* usually means the processing of data by machines.

Unit Record

The growth of today's data processing ideas and equipment has come out of the work done by Dr. Hermann Hollerith of the U. S. Census Bureau. Dr. Hollerith was in charge of counting and grouping all the people in the United States. Using this information, he wrote reports showing the ways that the country was growing. By 1887, he saw that it would be impossible to complete the work of the Census Bureau by hand in the legal time allowed. Dr. Hollerith saw that his job was counting all the people in our country in different ways. First, his department would count all the people, then only the men, then only the women, and so on. Each time a count was made, the original report for each person would be used. Each time, the information about each person was counted by hand. Dr. Hollerith saw that if data could be counted by machines and sorted into different groups, counts could be easily made. This led to his invention of the *punched card.*

The first punched card was a piece of cardboard into which holes were punched. If the top row were punched in the extreme left of the card, this might mean a man. If the second row were punched, this might mean a woman. In the same way, other data could be punched on the cards. For the 1890 Census, cards were punched for every person in the country. By using machines to sort and count people into groups, Dr. Hollerith completed the 1890 Census in three years. Manually it would have taken almost ten years. Each card contained all the data belonging to one person. This card became known as a *unit record.*

The original cardboard card has changed a little. Rectangular holes are punched now instead of round holes. The card size has been *standardized* (made the same size). It is now used to help in the planning, organizing, and controlling of manufacturing companies. Let us look at the *coding* (what the punched holes stand for) of the card.

The Card

Today the coding of the unit record punched card has been standardized. It is fairly easy to learn. The card is divided into 12 rows and 80 columns. The *rows* (horizontal lines) are numbered from top to bottom: 12, 11, 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. The top three, 12, 11, and 0, are called *zones.* The bottom nine, 1 through 9, are called *nu-*

meric, Fig. 31-1. The columns are numbered 1 through 80 from left to right. Each column can contain in coded form either one alphabetic letter, one numeral, or a special character such as the dollar sign ($), the period (.), or the comma (,). A single punch in a column is used to code a plus (+) sign (12-zone punch), a minus or a dash (—) sign (11-zone punch), or any single numeral from 0 to 9, Fig. 31-2. A *zone* and a *numeric punch* in a single column are used to code a letter of the alphabet, Fig. 31-1. A 12-zone punch and a 1-numeric punch in the same column are used to code the letter "A". The letter "B" is coded by the 12-zone and the number-2 punch. "C" is coded by 12 and 3. "D" is coded by 12 and 4, and so on. The letter "I" is coded by 12 and 9. The letters "J" through "R" use an 11-zone combined with a numeric punch. The last third of the alphabet (S through Z) begins with the 0-2 combination for "S" and ends with the 0-9 combination for "Z". The top of the card can contain printed *characters* (signs) that tell what the codes are in certain columns.

On the cards, reserved areas (called *fields*) are used for the punching of data. For example, data made up of five alphabetic or numeric characters would be punched into the same five columns of all cards describing the same item. The numeric quantity of each item in stock would be punched into certain other columns. Now that a unit record is made up, what can be done with it?

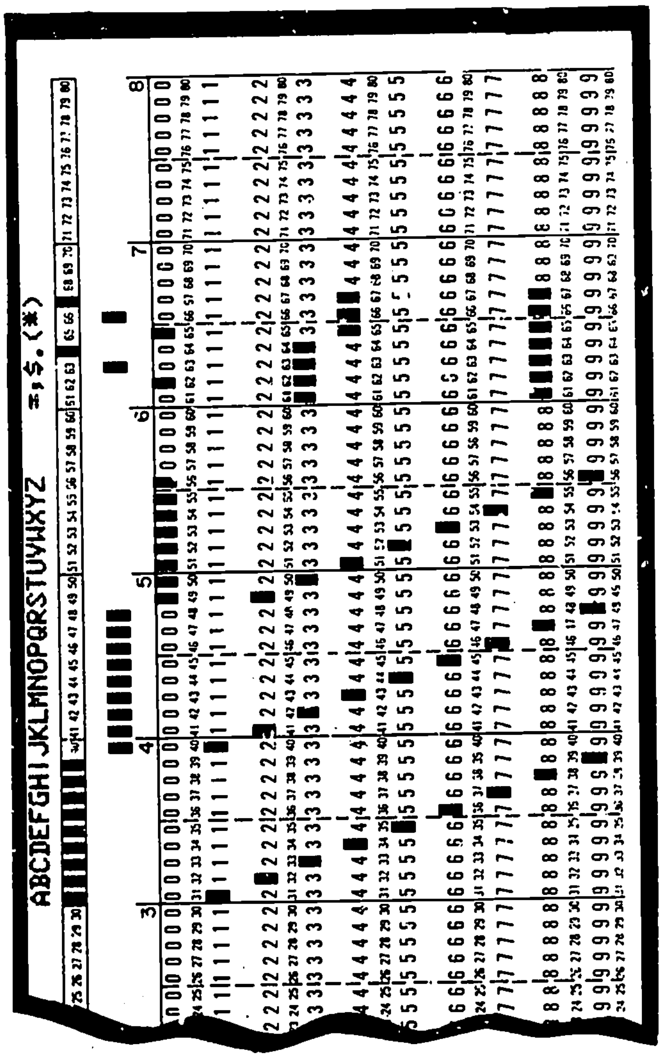


Fig. 31-1. A zone punch and a single punch in the same column are used to code a letter of the alphabet.

Processing of Data

The cards are processed through special machines. These machines can pick out the presence or absence of holes in the cards,

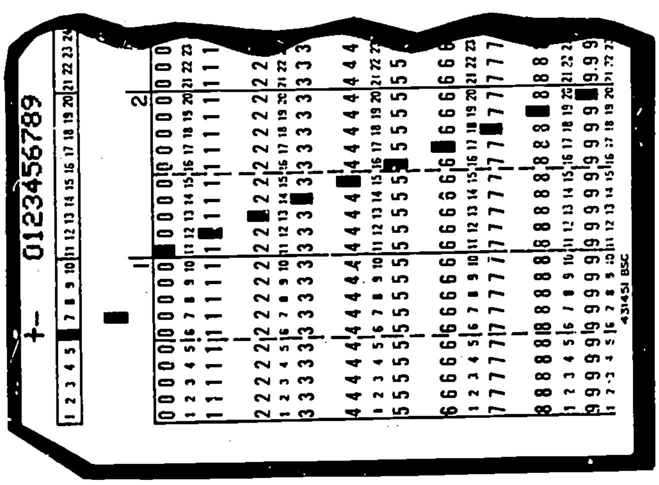


Fig. 31-2. A single punch in a column indicates +, —, 0, 1, 2, . . . , or 9 as shown in the illustration.

Fig. 31-3. These special machines perform four basic functions:

1. *Recording,*
2. *Classifying,*
3. *Calculating,* and
4. *Summarizing* (Fig. 31-4).

Recording Function

Coded data can be punched into a card manually (by hand), using special *pre-perforated* cards called *Port-a-Punch cards.* However, in most instances the codes are automatically punched into the cards by a machine. It looks like a typewriter and is called a *key punch.*

Classifying Function

Once cards are punched, they can be regrouped in two ways. A group of cards can be put into different order by a *sorter*, Fig. 31-5. A second way of regrouping is by using a *collator*. This machine can take two groups of cards, *match* them (make sure both groups are the same) and *merge* them (shuffle them together in some order). It can do other things as well.

Calculating Function

The *calculator* is a machine that can pick out numeric coded data on a series of cards. Then it can either add the data together, subtract one from another, multiply totals together (by rapid addition), or divide one number by another (by rapid subtraction). The results of these operations are usually punched into new cards. Much of the processing done by the calculator is now done by the *electronic computer.*

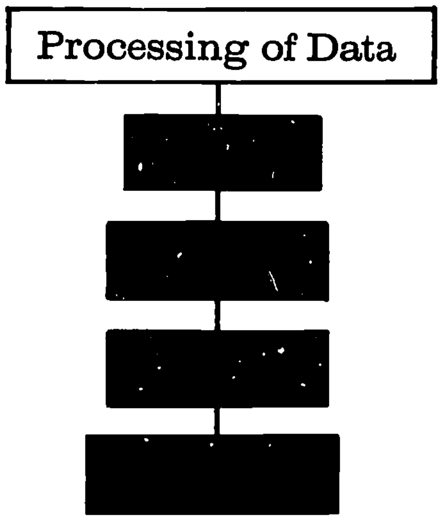


Fig. 31-4. Data processing machines perform four basic functions.

Fig. 31-3. These machines process data. They sense the presence or absence of holes in the punched cards.

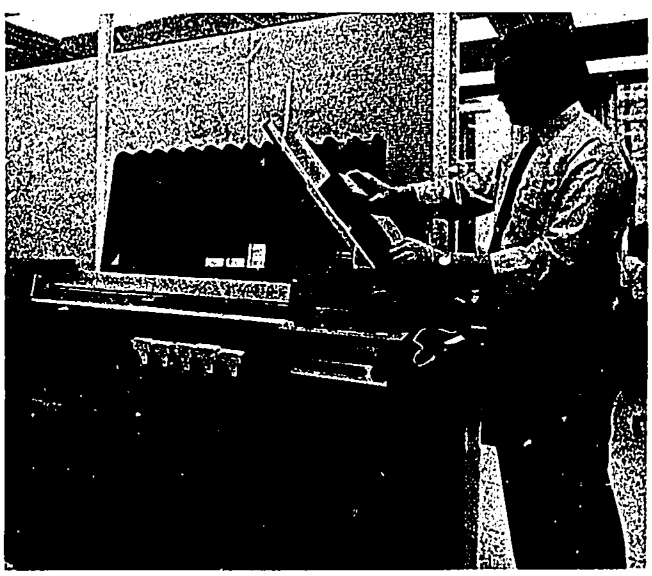


Fig. 31-5. This employee is operating a sorter.

Summarizing Function

The printing of reports that come from the data punched into cards is done by an *accounting* (tabulating) *machine.* The accounting machine can also do simple calculations such as the addition or subtraction of numbers. These are the important machines used in the processing of data in the form of a unit record.

Occupations in Data Processing

There are several different groups of workers in unit record data processing. There are the *key punch operators.* They are the people who record data into punched cards, Fig. 31-6. There are the *operators* who *sort* cards, *collate* (put together) decks of cards, and operate the calculators and the accounting machines to produce reports. Another group of people wires the *control panels* for the accounting and other machines. *Technicians* with a knowledge of mechanics and electronics are needed to keep the machines in repair, Fig. 31-7. Daily, more and more people are needed in this field.

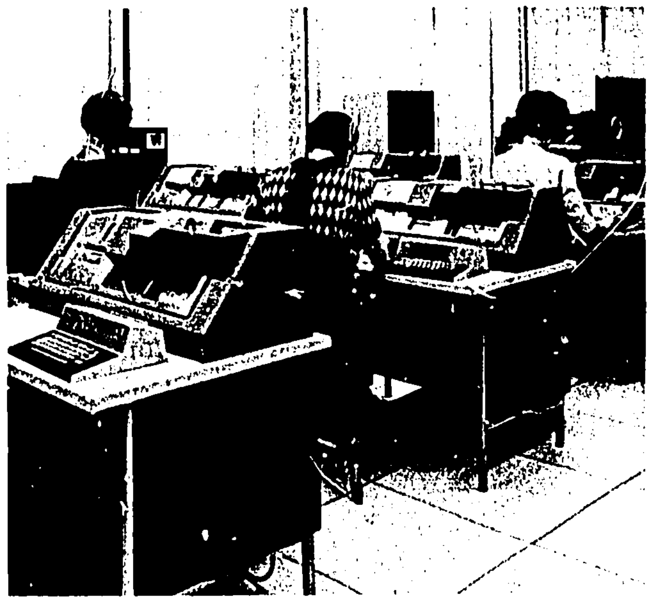


Fig. 31-6. There are many key punch operator jobs in data processing.

Fig. 31-7. Technicians are needed to repair, service, and clean data processing equipment.

Summary

The alphabet, numbers, and special symbols can be coded on a unit record card. The unit record cards are then processed by data processing machines. The four basic functions or operations of data processing are: (1) *recording,* (2) *classifying,* (3) *calculating,* and (4) *summarizing.*

Today data processing *concepts* (ideas) are being used in most companies, large and small. For intelligent decision-making on the part of management, it is necessary for all important facts to be known so that changes may be made. Some companies have gone out of business because management did not know the company was losing money.

Manufacturers use data processing tools in many ways. They are used to prepare payrolls, financial statements, bills, inventories, sales reports, etc. In the future, more use will be made of these tools. They can be used for *forecasting* (predicting) sales, product design and development, production planning, production control, personnel, and management decision-making.

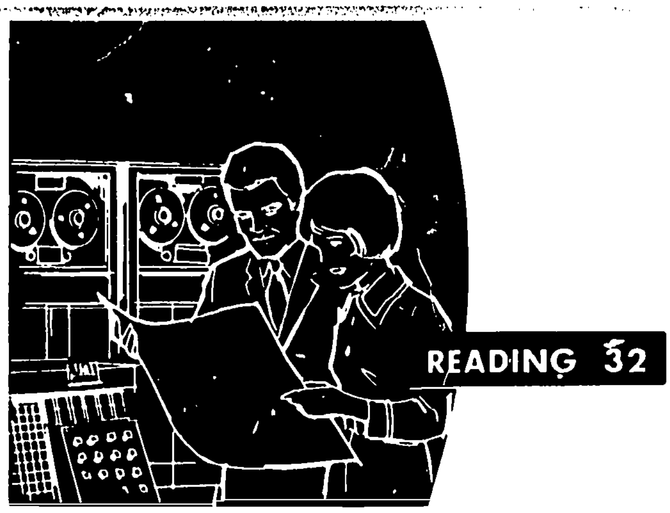
Terms to Know

data
information
data processing
manually
punched card
unit record
standardized
coding
rows
zones
Port-a-Punch cards
key punch
sorter
collator
  a. match
  b. merge
calculator
electronic computer
accounting (tabulating) machine
numeric
numeric punch
characters
fields
recording
classifying
calculating
summarizing
pre-perforated
key punch operators
operators
sort
collate
control panels
technicians
concepts
forecasting

Think About It!

1. Why do data cards carry the message: "Please do not bend, fold, staple, or otherwise mutilate this card"?
2. If *data processing* eliminates the need for human beings to do what machines can do quicker and more accurately, what happens to the people who used to do these jobs?

Using the Computer



From the earliest times man has always wanted to know how many or how much. At first he counted on his fingers and toes. Later he used stones to keep track of things. He also made marks on the earth or on the walls of his cave. Soon his possessions grew in number. He invented machines to help him in his *calculations* (arithmetic). The earliest of these machines was the *abacus,* made of a series of beads on wires. It is still used in the Orient.

Around 1822, Charles Babbage, an Englishman, used the fact that figuring with numbers is doing the same thing over and over again. He thought a machine could be made that would *automatically* operate on numbers of any kind to get answers. He tried to build an *analytical engine.* It would first accept all the directions to complete a calculation. Then, using whatever data were given to it, it would perform all the operations without any human help. His idea was a good one. The mechanics and technicians of those days, however, were not skilled enough to make it work. This was the first idea for a *stored program computer.* Modern *electronic technology* developed in the late 1940's. Then Babbage's ideas were put to use when the EDVAC (Electronic Discrete Variable Automatic Computer) was built. Many newer computers are now in use.

The Electronically Stored Program

The *electronic computer* is made up of several different parts. These are:

1. *Input,*
2. *Central processing unit,* and
3. *Output,* Fig. 32-1.

You will learn about each part and how all the parts work together to give man a powerful *computational* (capable of figuring) and *decision-making* tool.

Input

Before any processing can take place, data must be put into the computer. There are several ways this is done today.

The first way is to punch the data or information into cards. Data are coded in the same Hollerith coding that is used for unit record data processing. These cards are then put into a machine called a *card reader.* The presence or absence of holes in positions of the card lets electric current flow into the *memory* of the computer. In this way data are stored in the computer's memory for processing.

Other kinds of input used are a *typewriter keyboard* connected directly to the

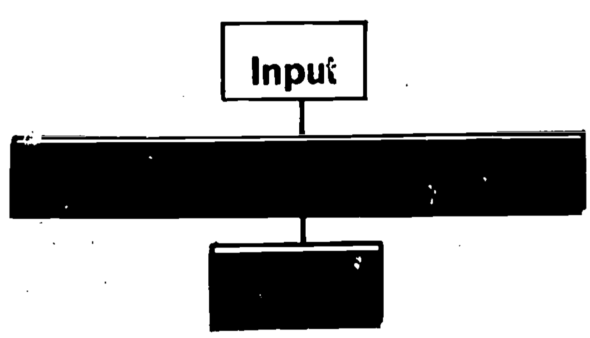


Fig. 32-1. These are the main sections of an electronic computer.

computer, Fig. 32-2; *punched paper tape readers;* and *magnetic tape readers,* Fig. 32-3. The punched paper tape is coded to cards. More than 80 pieces of data can be punched into the paper tape. Paper tape is also used a great deal in numerical control of machinery. Magnetic tape used in computers is very much like the tape used on voice tape recorders. Instead of voice and music, coded alphabetic and numeric *characters* (signs) are read from the tape.

Central Processing Unit

Data are "read" by one of the sensing units of the central processing unit (c.p.u.). The central processing unit is made up of four sections:

1. *Control,*
2. *Memory,*
3. *Arithmetic,* and
4. *Logic,* Fig. 32-4.

All operations, including the reading of data, are under the *control* section of the central processing unit. This part of the computer is like a railroad yard. *Switches* are opened and closed to make the system do certain things, Fig. 32-5.

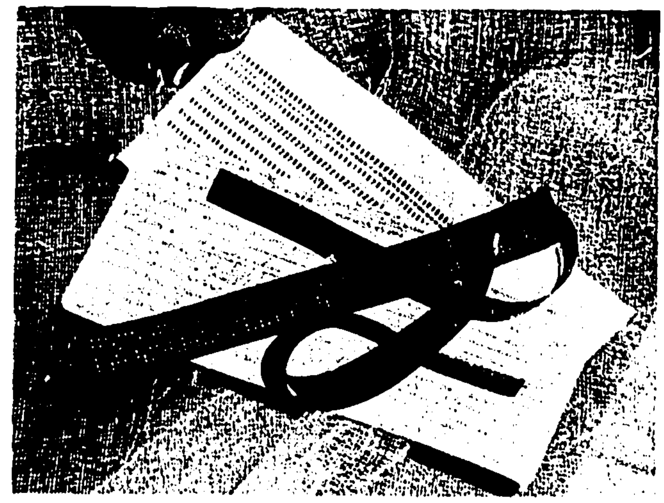


Fig. 32-3. Samples of punch cards, paper tape, and magnetic tape used for feeding input into a computer are shown.

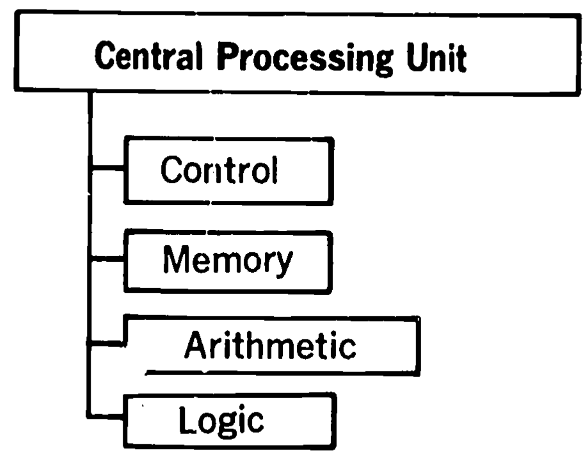


Fig. 32-4. These are the four main sections of the central processing unit (c.p.u.).

Fig. 32-2. This typewriter keyboard is a means of feeding input into a computer.

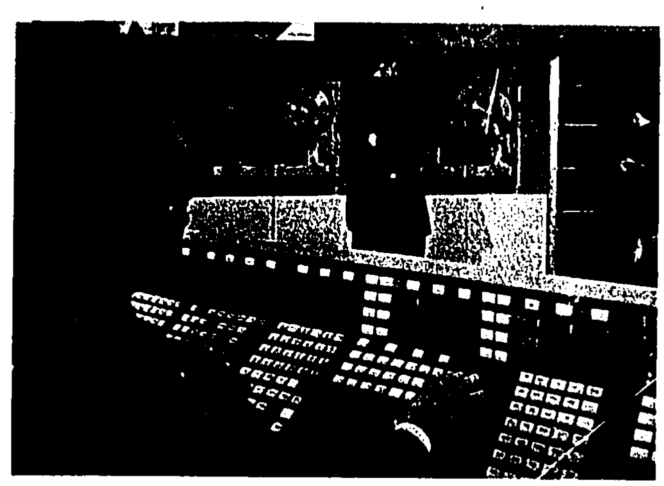


Fig. 32-5. This operator is controlling the computer.

Before any processing can take place, data must be fed into the computer. So, data are stored in the *memory* system of the computer. The data are stored as electric or magnetic *impulses* (forces) in coded form, Fig. 32-6.

Most of the processing done by a computer is the addition, subtraction, multiplication, and division of numbers. There are a series of *circuits* (paths) in the central processing unit which do these operations. Only two processes are used, addition and subtraction. These are in the *arithmetic section.*

The computer can also be told to make certain simple logical decisions. Is one number the same as another? Is one number smaller (or larger) than another? Is the job finished? As these questions are answered, certain switches are set. Then either one operation or another will take place. These particular circuits (paths) are in the *logic section.*

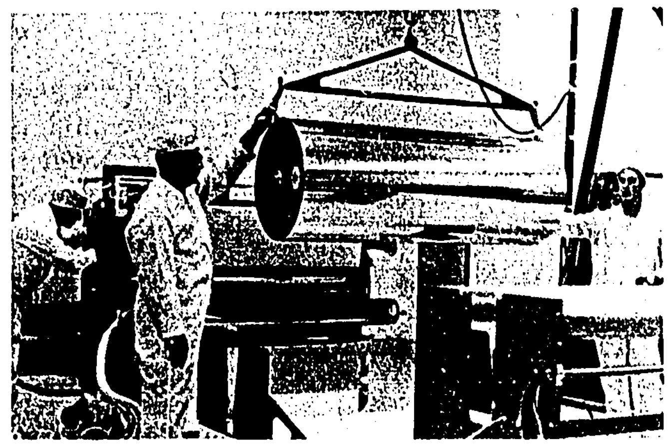


Fig. 32-6. This memory drum of a computer will store thousands of data.

Output

After the data are processed, they must be put into a form which man can use. The most common form of *output* is the printed page, Fig. 32-7. The typewriter which was used for input can also type the output. A high-speed *printer* can print up to 1200 lines in one minute. Each of these lines can have as many as 132 different alphabetic or numeric characters.

If the output of a computer is to be further processed, it can be done automatically in coded punched cards or on magnetic tape.

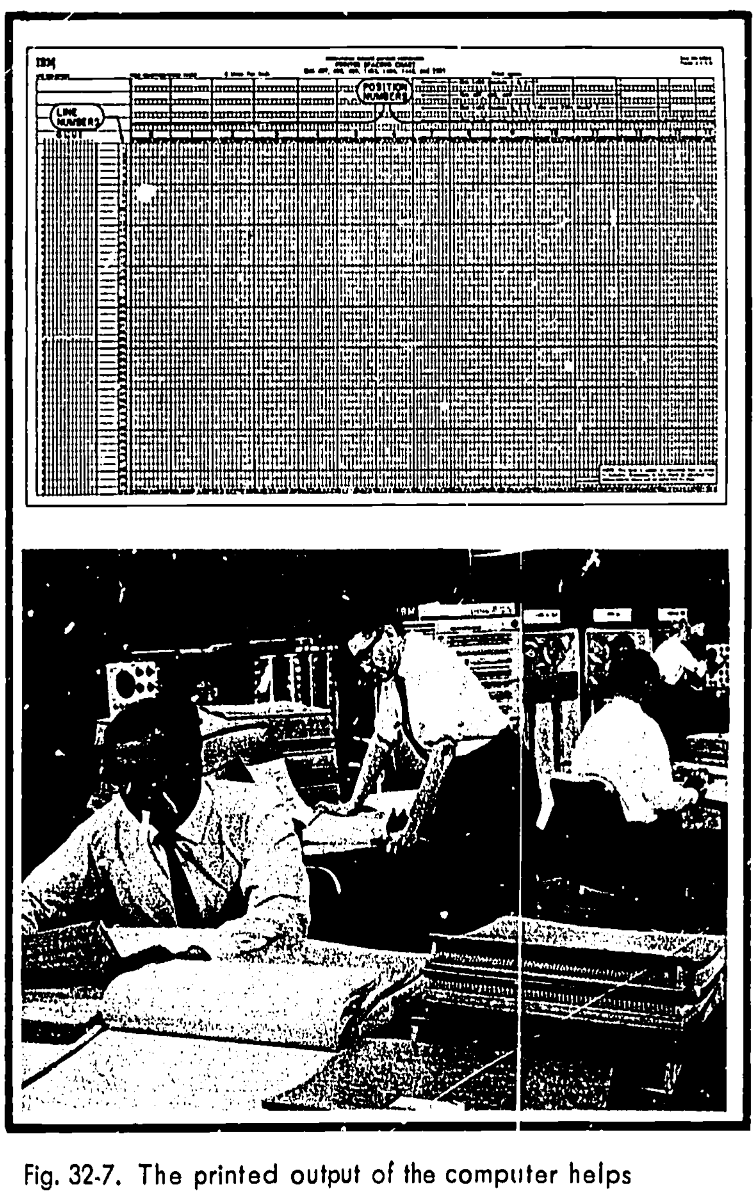


Fig. 32-7. The printed output of the computer helps men to use the data.

Controlling the Computer

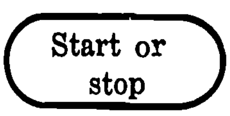
The computer is basically thousands of electrical or electronic switches which are either open or closed. These switches are set by the person controlling (*programming*) the computer. The programming of the computer is the most careful work done by people in this field.

Programming

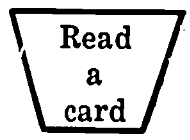
The first step in programming a computer is so simple that most people would not even think of it. *You must decide what the problem is.* Once you understand the problem, then you can decide:

1. What data can be collected and stored,
2. What the end result of the processing is to be, and
3. What exact steps must be followed to get these results.

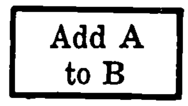
Programmers have developed a set of *symbols* and a procedure to help them see the ways to solve problems. The procedure is called *flowcharting.* This shows the flow of data through various operations, Fig. 32-8. Here are some of the most common symbols used for flowcharting.



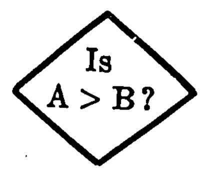
The *oblate* (flattened circle) is used to show either the beginning or end of a problem solution.



The *trapezoid* is used to show some input (read a card, read paper tape) or output (punch a card, punch paper tape) operation.



The *rectangle* is used to show what should be done to the data.



(> means "greater than")

The *diamond* is used for decision points. These are places in the program where more than one type of processing can take place. The decision depends on the results of an earlier operation. If a change of procedure from the normal is needed, this is called *branching.*

Arrows are used to show the flow of data.

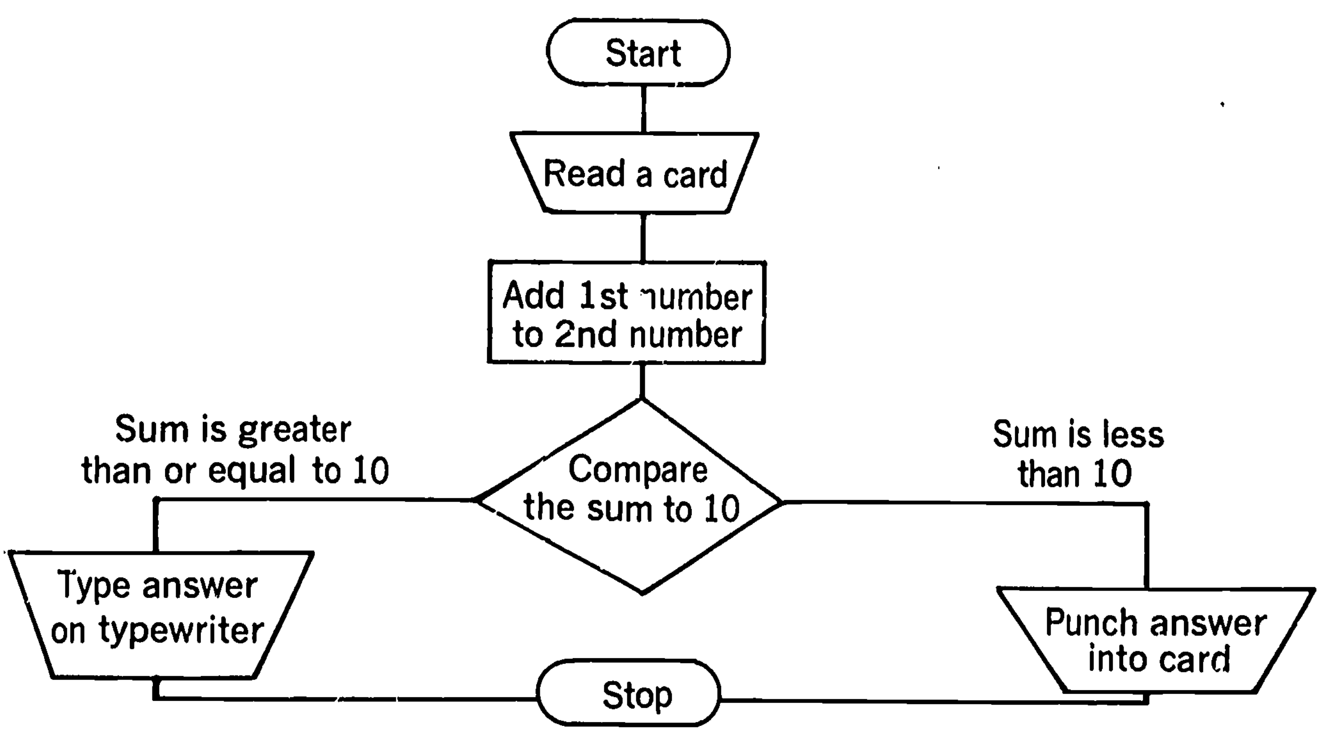


Fig. 32-8. Symbols and a procedure help programmers solve problems.

Let us see how a flowchart is made to solve a simple problem.

The Problem: Punch 2 numbers on a card. Add them together. If the sum is less than 10, punch the answer into a card. If the answer is equal to or greater than 10, write the answer on the computer typewriter.

The flowchart for this problem is shown in Fig. 32-8.

When the flowchart is finished, the computer program is written. The program can be written in several different languages. Learning these languages is just as hard as learning French or Latin. In English, however, a program to solve the problem which was flowcharted in Fig. 32-8 would look like this:

1. Start.
2. Read a card.
3. Move the two numbers to two memory positions.
4. Add the two numbers together.
5. Put the sum in a position of memory.
6. Create the number "10" in a position of memory.
7. Compare the sum to the number "10".
8. If the sum is greater than or equal to 10, go to step 9. If the sum is less than 10, go to step 11.
9. Type the answer on the computer typewriter.
10. Go to step 12.
11. Punch the answer in a card.
12. Stop.

As you can see, even a simple program such as this has 12 steps. Programs are written to solve manufacturing inventory or production problems. Often there are from 10,000 to 15,000 separate steps.

Advantages of Computers

It seems hardly worth the effort to write a program to add two numbers together. But suppose the problem is to add together one million sets of numbers. Once the program has been written, the computer can automatically repeat the same process over and over many times. It can add together each two numbers in the million sets in almost the same time it would take you to add 100 numbers together. One advantage of the computer is that it does not get bored or tired. Another advantage is that it usually does not make mistakes.

Remember that a computer is programmed to solve a problem in a definite way. The program does not depend on the data themselves. Once the program is written, it is then placed or "read" into the computer memory. When data are ready for processing, man is no longer in charge. The computer will repeat the job over and over again until the program tells it to stop.

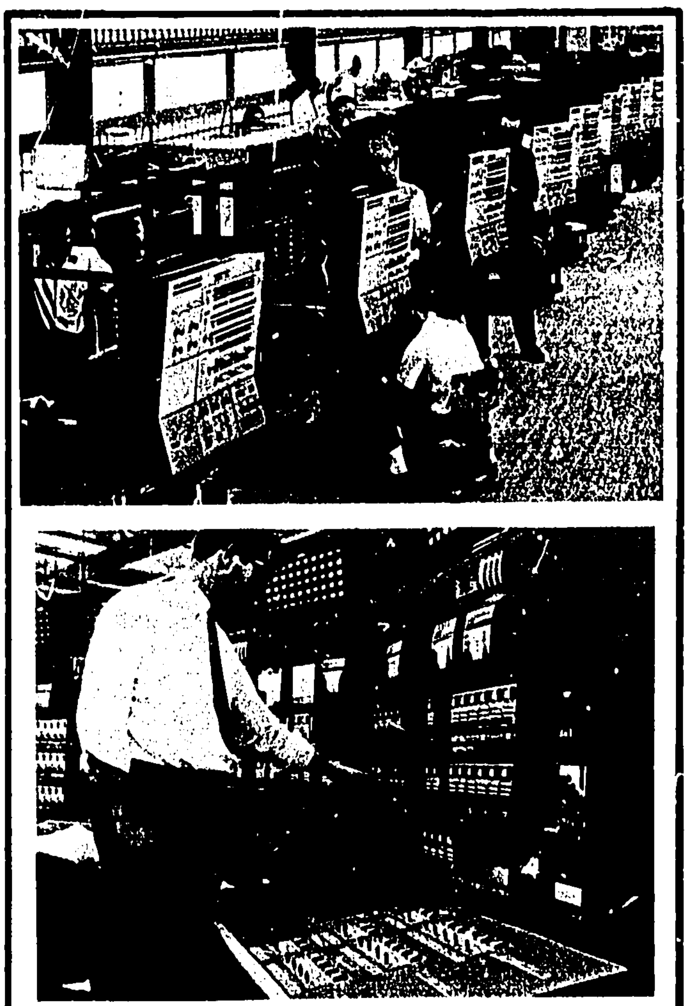


Fig. 32-9. There are many jobs for people in building computers (top) and operating computers (below). Will you find your future in the computer field?

Job Opportunities

Computer technology is perhaps the fastest growing employment field today, Fig. 32-9. There is a need for people to define problems and develop solutions. These people are called *systems analysts*. The people who write the instructions the computer will follow are called *programmers*. Because the computer is made of thousands of transistors, resistors, circuits, and other electronic devices, there is a great need for *technicians* to keep the computers working.

Manufacturing and the Computer

In manufacturing, computers have found their greatest use in repetitive *clerical* (record keeping) types of work. *Accounting* and *payrolling* are two examples. The computer is very useful in *sales forecasting* (predicting). More and more uses are being discovered in production *planning* and *controlling*. Some use is being made of computers in product design. Quality control systems are more effective by using computer techniques. In actual production processes, special purpose computers have been very successful in directing machine operations.

More and better uses for the computer will be found. In the future, managers will make more use of the computer for making decisions. Its use in research and development will grow.

Summary

The electronically stored program computer is a machine made up of thousands of switches and circuits. After programming it is able to repeat a procedure over and over again without any further help from man.

The computer has three main sections:

1. Input, which puts data into the computer;
2. The central processing unit, which includes control, memory, arithmetic, and logic sections; and
3. Output, which makes the results of data processing useful to man.

Once the program is written, it is placed in the memory of the computer. Then the computer can automatically process data fed into it. Under the direct control of man, this machine can do jobs that allow him to better live in and understand the world about him.

Terms to Know

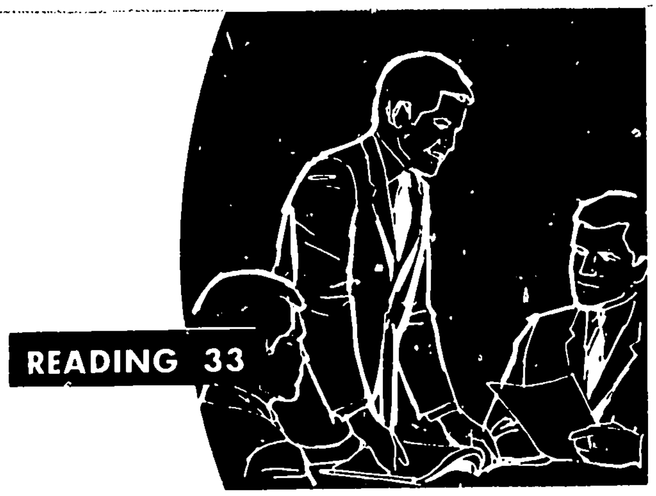
calculations
abacus
automatically
analytical engine
stored program computer
electronic technology
electronic computer
input
central processing unit (c.p.u.)
  a. control
  b. memory
  c. arithmetic
  d. logic
output
computational
decision-making
card reader
typewriter keyboard
punched paper tape readers
magnetic tape readers
characters
control
switches
memory system
impulses
circuits
arithmetic section
logic section
printer
programming
symbols
flowcharting
oblate
trapezoid
rectangle
diamond
branching
arrows
computer technology
systems analysts
programmers
technicians
clerical
accounting
payrolling
sales forecasting
planning
controlling

Think About It!

1. Besides adding and subtracting, what can a computer do? Can it do more than man directs it to do?
2. Can you list three things that a computer did for you and your family last week?

Using the Computer

- [redacted]
  - Identifying problem
  - Flowcharting
  - Writing program
- [redacted]
  - Cards
  - Tapes
- [redacted]
  - Control
  - Memory
  - Arithmetic
  - Logic
- [redacted]
  - Printed Page
  - Cards
  - Tapes



Employment and Occupations in Manufacturing

Slightly over one-fourth of all the labor force in the United States works directly in manufacturing. Many more people work in jobs that are indirectly related to manufacturing.

After raw materials have been gotten from nature, different manufacturing industries *convert* (change) these materials into useful products. Customers get these products by different means of trade or *distribution*. In this reading you will learn about manufacturing employment and occupations. This large group stands between the raw materials and the distribution of manufactured products.

Relationship of Manufacturing Employment to the Labor Force

In 1966, manufacturing in the United States employed almost 15 million people. This is more than any other *category* (group) of employment. There were 59,738,000 nonagricultural workers in the United States in 1966, and 5,047,000 agricultural workers. Figure 33-1 shows how many people worked during 1966 in manufacturing, *wholesale* and *retail* trade (in which goods are sold to stores, and stores then sell them to the consumers), government jobs, mining, and other occupations. The graph does not

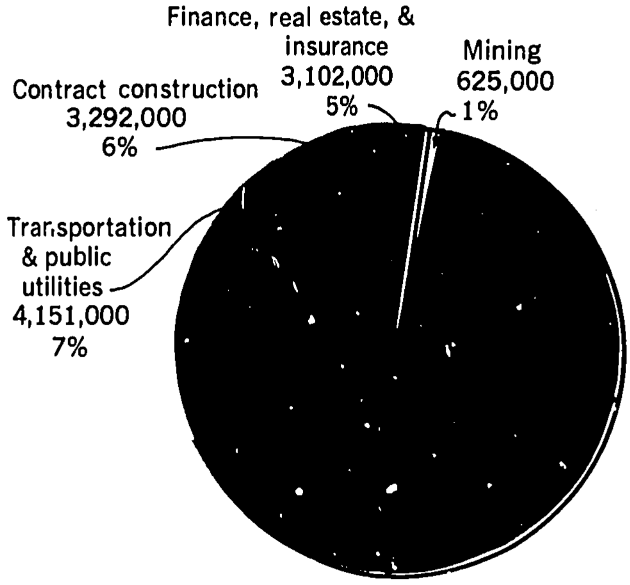


Fig. 33-1. Numbers of workers in manufacturing and other fields during 1966 are shown. Agricultural workers are not included.

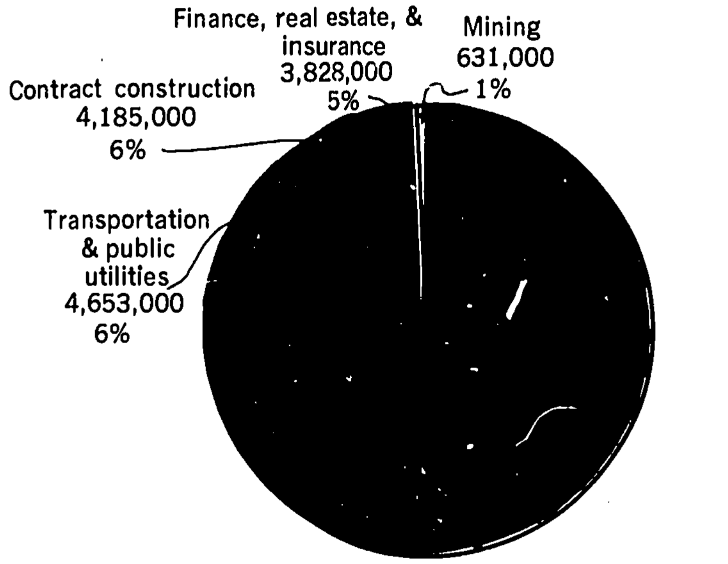


Fig. 33-2. Numbers of workers in manufacturing and other fields are *estimated* for the year 1975.

EMPLOYMENT GROWTH BY INDUSTRY GROUPS
Percent Change 1965 to 1975 (Projected)

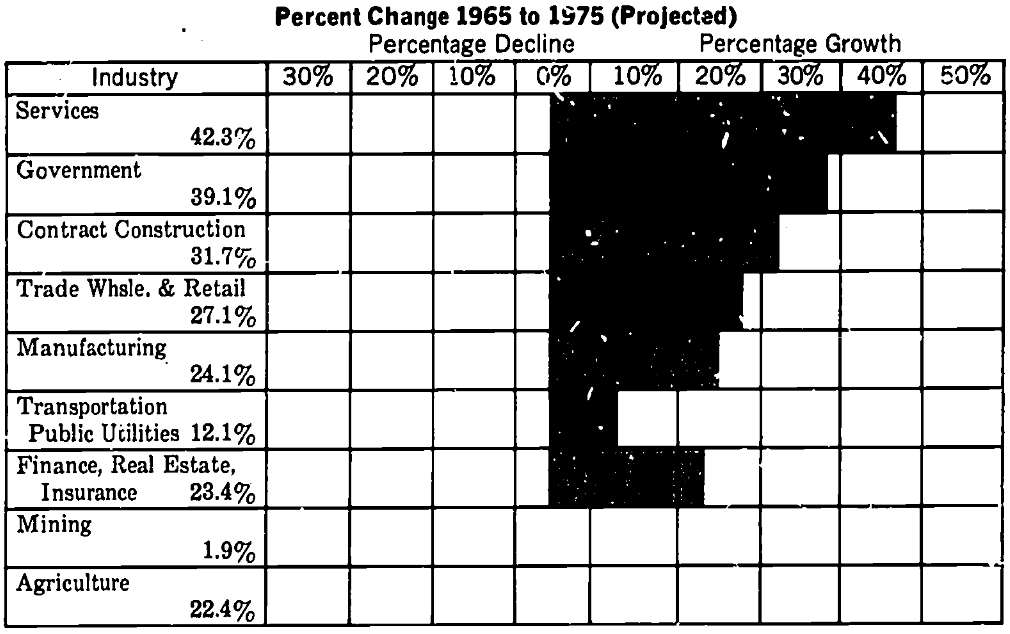


Fig. 33-3. Estimated percent of change in employment, from 1965 to 1975, in manufacturing and other fields.

show those who worked in agriculture. By 1975 this group of nonagricultural employees should reach 78,515,000. The number of agricultural workers should fall to 3,917,000 by 1975. Figure 33-2 shows how many people should be in each group during 1975. Employment should increase by almost 19 million workers between 1966 and 1975. But the percentage of people in each occupational group will probably stay about the same. This means that the total nonagricultural employment in 1975 will have increased by almost 19 million. The percentage changes within groups of occupations, however, will be very small.

Another survey has *estimated* (figured) the employment growth and decline in major areas from 1965 to 1975, Fig. 33-3.

Youth in the Labor Force

The number of workers in each age group of the *labor force* is changing. Figure 33-4 gives the change in the number of workers within a particular age group for the years 1955, 1965, and the estimates for 1975.

Figure 33-4 shows that the total labor force will increase in nearly all age groups

LABOR FORCE IN THE UNITED STATES
The Numbers Represent Millions of Workers

Age Group	1955	1965	1975 (projected)
Under 25	11.85	15.65	21.10
25-34	15.73	14.99	21.09
35-44	15.04	17.23	16.29
45 & Over	24.85	29.31	33.75
	68.07	77.18	92.23

Fig. 33-4. Labor force in the United States. The numbers stand for millions of workers.

from 1965 to 1975. But the 35 to 44 age group will decrease. The largest increases are in the younger age groups of under 25 and the 25 to 34 group. The group under 25 will increase 34 percent. The 25 to 34 group will increase 40 percent. These younger age groups in 1965 made up about 39 percent of the total labor force. In 1975 they should be about 46 percent of the labor force. This will be an increase of about 7 percent.

The new workers in the younger age groups will be better trained. For example, in the age group of from 25 to 34, there will be only about 30 percent with less than a high school education in 1975. In 1965 this figure was about 37 percent. This means that 7 percent more workers will have at least a high school education.

Education and training will be important throughout life. In the future, a person must be both a worker and a learner throughout his working years.

Categories of Manufacturing Employment

Manufacturing employment may be divided into two main categories:

1. *Durable goods* employment, and
2. *Nondurable goods* employment.

Durable goods are products that have a life of three years or more. Nondurable goods are goods that last less than three years.

In durable goods manufacturing, there are ten categories. They are *ordnance* (weapons and ammunition); lumber and wood; furniture; stone, clay, and glass; primary metals; fabricated metals; electrical equipment; transportation equipment; instruments; and machinery. Figure 33-5 shows the number of workers in each category.

In nondurable goods manufacturing, there are also 10 categories. They are food; tobacco; textile mill; apparel; paper; printing and publishing; chemicals; petroleum; rubber; and leather. Figure 33-6 shows the number of workers in each category.

1970 Employment in Durable Goods Manufacturing

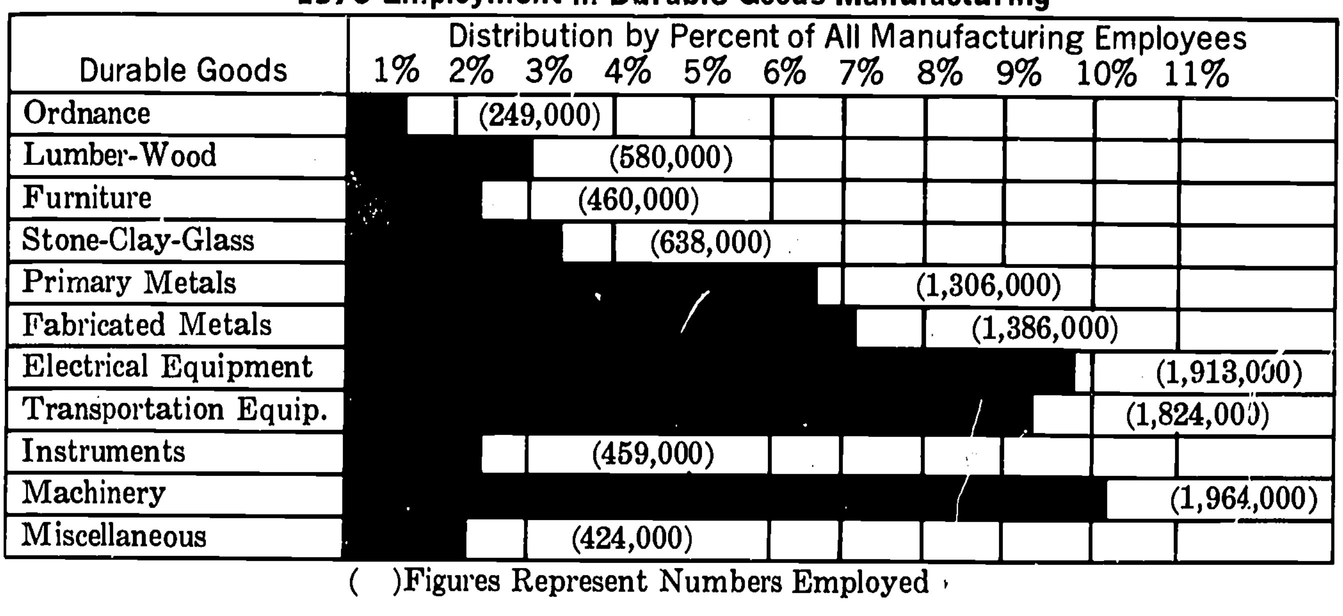


Fig. 33-5. The 1970 employment in durable goods manufacturing is shown.

By 1975 the total employment in tobacco, petroleum, leather, and lumber and wood will decrease. All of the other 16 categories will increase. Printing and publishing will increase the most.

Production Occupations

A production worker works in a plant, factory, or mill that changes *crude* (raw) materials into goods for human use. Production workers *directly* add value to raw materials by changing the form of materials. Production workers can be grouped as *unskilled, semiskilled,* and *skilled,* Fig. 33-7.

The unskilled worker does very simple jobs. Today industry needs very few unskilled workers.

Most manufacturing production employees are semiskilled. They use machines to stamp out or shape metal parts. They run power driven equipment. They assemble parts of a product. They drive fork lift trucks. They load conveyors with proper parts. These are examples of the many jobs that semiskilled workers do.

There is a shortage of workers in skilled jobs in manufacturing. This includes machinists, job setters, toolmakers, lathe operators, plumbers, electricians, welders, millwrights, draftsmen, and others. These workers usually go through an *apprenticeship* (learning) program. They often spend a number of years learning their work. Skilled workers are the highest paid production workers.

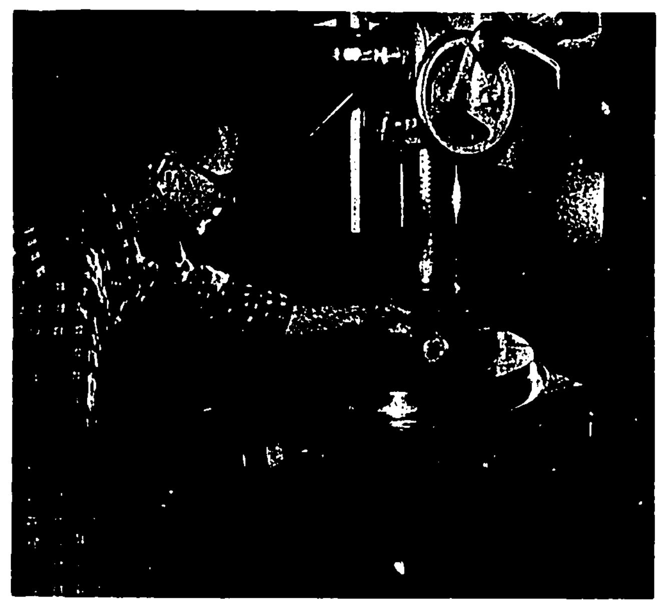
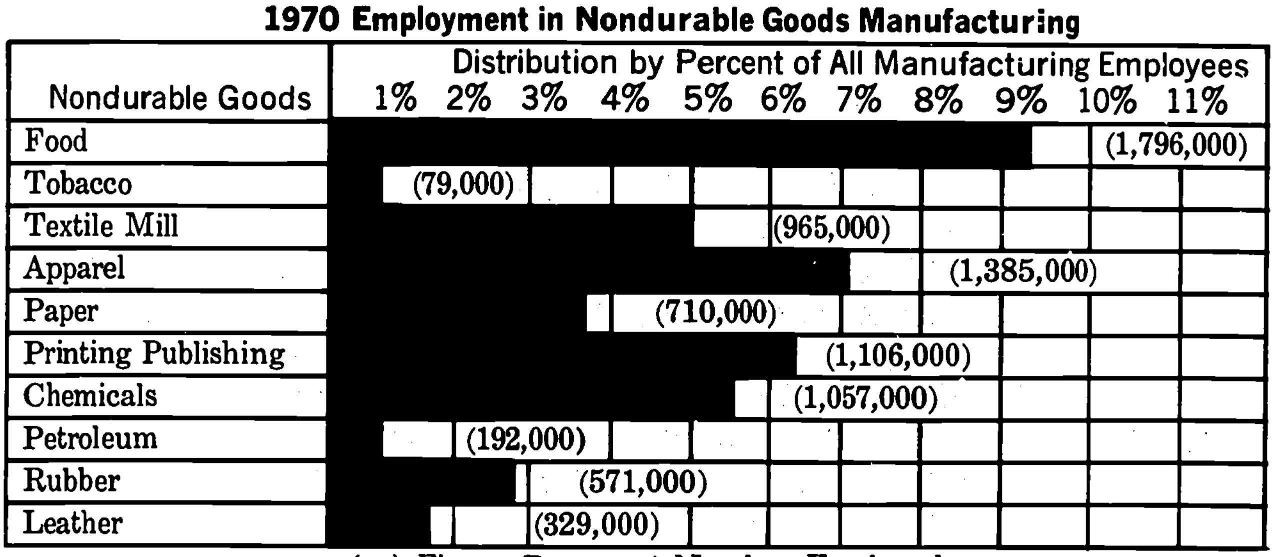


Fig. 33-7. Most production workers are semiskilled or skilled.

1970 Employment in Nondurable Goods Manufacturing



( ) Figures Represent Numbers Employed

Fig. 33-6. The 1970 employment in nondurable goods manufacturing is shown.

Managerial Occupations

Managerial occupations are fewer in number than *production occupations*, but they are a very important part of the manufacturing labor force. The employees of the management group usually have more education than the production workers. This education includes college, junior college, business college, trade and technical schools, or correspondence schools, Fig. 33-8.

The general functions of management are *planning*, *organizing*, and *controlling*. Different groups work at *management* jobs. Managers do not *directly* add value to materials. They *indirectly* add value.

The top management job, under the *president*, may be the *vice-president and general manager*. He is in charge of the whole company's work. The *manager of manufacturing* reports to the general manager. He is in charge of producing the company's products. Several *shop superintendents* report to the manager of manufacturing. Each one is in charge of a part of the production. The *general foreman* reports to the shop superintendent. He is in charge of one or more departments. The *shop foreman* reports to the general foreman. The shop foreman is directly in charge of *production workers*, Fig. 33-9. He is in charge of getting the workers to do their job in the most efficient way.

The *personnel manager* and his staff are in charge of all the personnel action of the

Fig. 33-8. Many management personnel have college degrees or special training.

Fig. 33-9. Many foremen started as production workers.

Fig. 33-10. Many clerical workers are needed in manufacturing.

company. Their jobs include hiring, training, working, advancing, and retiring practices. The work of the personnel department is part of management.

All people in engineering jobs perform management functions. Production planners indirectly add value to the product. Quality control people perform important management jobs. They are in charge of the quality of the company's products. They actually take the place of the customer in the plant. Production control jobs include getting, moving, and shipping the company's products to the customers. Other workers in this area are the *traffic supervisor, material handling supervisor, shipping foreman,* and *receiving foreman.*

Engineers need *technicians.* For every engineer a company hires, from three to ten technicians are hired. There is a very great shortage of technicians in industry. A technician usually has one or two years of education beyond high school.

Workers in marketing, advertising, sales, accounting, and purchasing indirectly add value to the product of the company. Many people do clerical work in offices in manufacturing, Fig. 33-10. These people could use their knowledge and skills just as well in businesses other than manufacturing.

Data, People, and Things

Occupations include a group of skills or jobs and the people who can do them. A new way to look at an occupation is to think of the individual "job" as tasks, skills, and abilities necessary to do the job well. This new approach to *job description* puts each job into three *divisions* (kinds) of performance: data, people, and things, Fig. 33-11.

Working with *data* includes such things as information, mental creation, work symbols, and ideas. Working with *people* includes exchanging ideas, teaching subject matter, supervising, persuading, or attending to the needs of people. *Things* have shape, form, and other qualities. They are such items as machines, tools, and equipment.

A value of from 0 to 8 is given to each division of *data, people,* and *things.* The value of 8 shows no importance to the job. The value of 0 shows great importance to the job. For example, a job with a value of 084 means:

1. The "data" division, value of 0, is very important for this job.
2. The "people" division, value of 8, is not important at all for this job.
3. The "things" division, value of 4, is of average importance to the job. See Fig. 33-12.

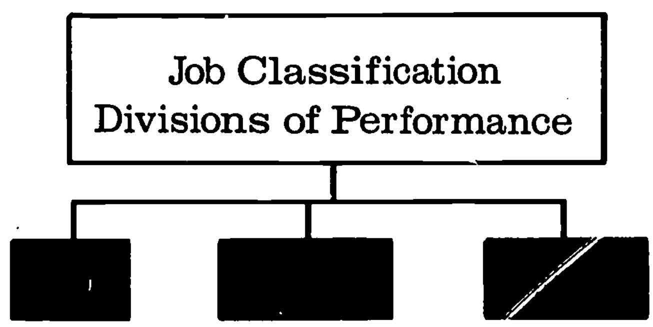


Fig. 33-11. Job classifications differ depending on how the employee works with data, people, or things.

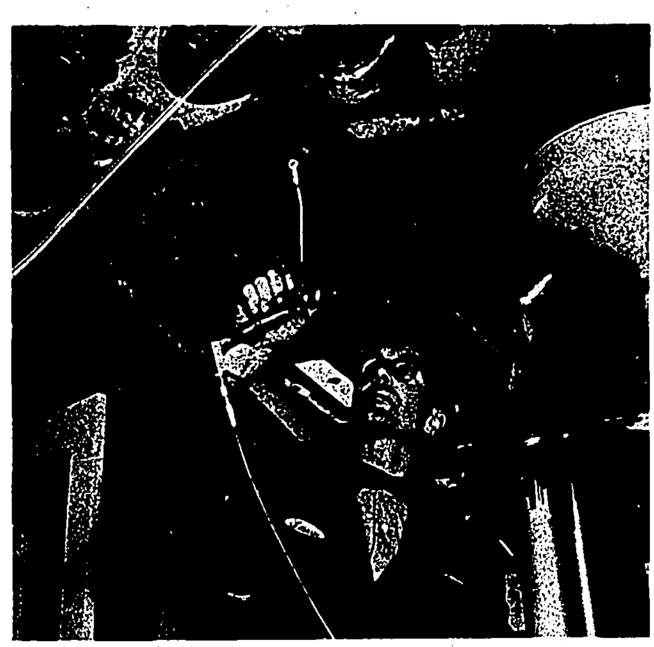


Fig. 33-12. This service station worker would have a high "thing" rating.

Other examples are: manufacturing engineers 187, building inspector 168, grinder setup man 380, and welder 381.

Summary

The total number of workers in the labor force will increase by almost one-third from 1966 to 1975. Service and government employment will increase the most. Only mining and agricultural employment will decline. Of the 20 categories of manufacturing employment, printing and publishing employment will increase about 30 percent more than the next largest category increase.

Our labor force is becoming younger. This means that we are getting more young people into the work force each year. The younger labor force will be better trained.

Production workers directly add value by changing the forms of materials. Production occupations are unskilled, semiskilled, and skilled. Most of the production labor force is semiskilled. The highest paid group of production workers is the skilled employee group.

Managerial occupations indirectly add value to the product by planning, organizing, and controlling the company's activities. Management jobs are well paid. Education beyond high school is usually needed.

Job classifications are now being made using three divisions of performance: data, people, and things. Jobs differ in how much work with data, people, or things they include.

Terms to Know

convert
distribution
category
wholesale
retail
estimated
labor force
durable goods
nondurable goods
ordnance
crude
directly
unskilled
semiskilled
skilled
apprenticeship
managerial occupations
production operations
planning
organizing
controlling
management
indirectly
president
vice-president and general manager
manager of manufacturing
shop superintendents
general foreman
shop foreman
production workers
personnel manager
traffic supervisor
material handling supervisor
shipping foreman
receiving foreman
engineers
technicians
occupations
job description
- a. data
- b. people
- c. things

divisions

Think About It!

1. Managers add value to products *indirectly*. How *do* managers add value to products?
2. Why do you think that service and government employees will increase the most from 1966 to 1975? Will manufacturing workers increase or decrease?

Manufacturing Personnel Technology

READING 34

Everyone's life in our country is touched by industry. You don't have to walk long distances to school. You can ride a car (a manufactured object) over a constructed highway. You don't have to worry about extreme heat or cold. Items of clothing protect you when you are outside. Inside you are protected by the building and its heating and cooling systems. You don't have to worry about food shortages. Seasonal food products and *surpluses* (extras) can now be kept until they are needed. The way people's lives are touched by industry is studied in some way in most of your school subjects.

The lives of about 25 million people (one-third of the total labor force) are affected directly by industry, Fig. 34-1. These people work in the factories and on the construction sites. They are called *industrial workers*, employees, or personnel, Fig. 34-2. They are affected by industry off the job in much the same way as other people are. Industrial workers also come into contact daily with *personnel technology* (practices) on their jobs. Some of these *practices* (techniques) are the same in manufacturing as they are in construction, but many of them are very different. All manufacturing workers and all construction workers are (1) *hired*, (2) *trained*, (3) *worked*, (4) *advanced*, and (5) *retired*. The practices used with all workers can be studied under these major headings.

Importance of Personnel Technology

A manufactured product may be well designed and engineered, but little will come of it unless able workers can be hired to make

Fig. 34-1. About 25-million Americans work in manufacturing and construction. Fitting the people to the right job is the work of the personnel department.

Fig. 34-2. During their working week, employees spend one-half of their waking hours at their jobs. Satisfaction is important.

it. *Hiring practices* are important. Suppose trained workers cannot be hired. Training must then be given workers to help them get the knowledge and skills they need to do the work. Fig. 34-3. Without this training, a new worker would have difficulty helping others make a product.

Suppose the people have been picked who can do the work. The *working conditions* on their jobs will help them decide whether or not they want to go on working there. Suppose they decide to stay. How long they stay, how happy they are, and how well they work all will be decided by their working conditions. It will not do much good to attract and hire good workers, if they will not like their working conditions enough to want to work well every day.

There are important reasons for workers staying a long time with one employer. One of these reasons is the kind of *advancement* and *retirement* practices that are used. If the workers feel they will be rewarded for good work and can look forward to retirement, they will be more likely to stay with their employer. What will be done with the people in the company must be *planned, organized, and controlled.* This is just as important as what is done with the tools, machines, and materials. People can be there for a lifetime, but most other resources are replaced much more often. People may be the most valuable resource a company has.

Personnel technology is usually thought of as something that has to do only with production workers. All levels and kinds of management personnel are also included, Fig. 34-4. They are hired, trained, worked, advanced, and retired. All manufacturing

Fig. 34-4. Personnel practices apply to all production workers and to all levels of management personnel, such as engineers and designers.

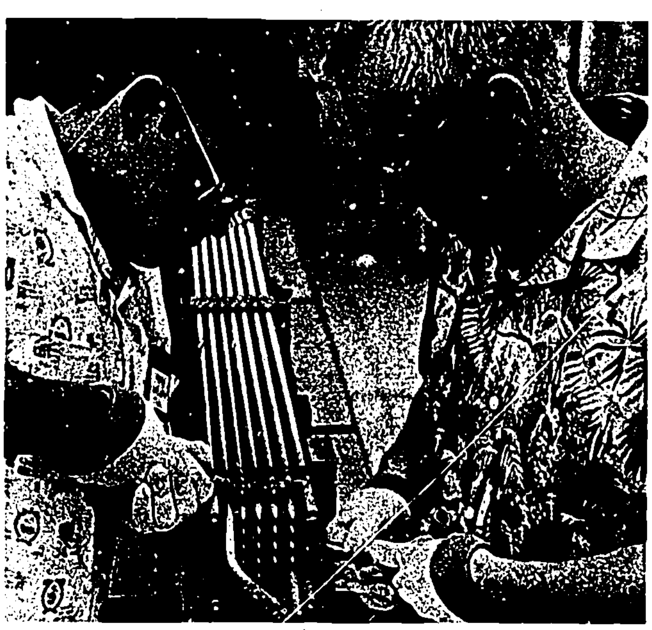


Fig. 34-3. Some skills are learned best on the job. Older workers train newer ones.

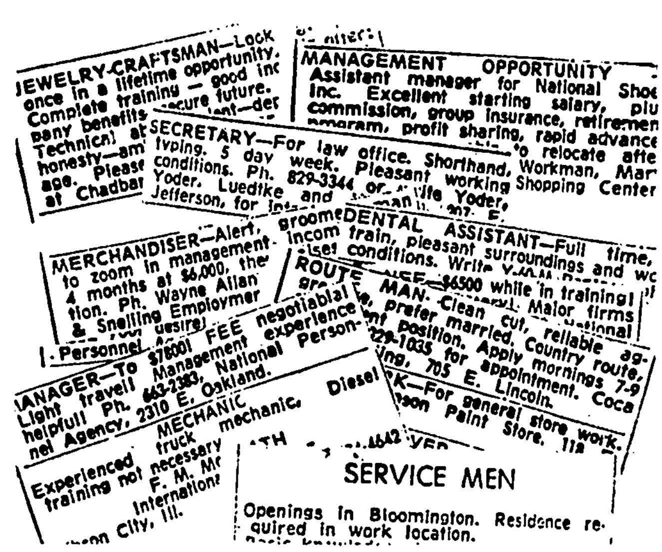


Fig. 34-5. Many methods are used to attract workers to manufacturing. Newspaper ads are often used.

workers are included in manufacturing personnel technology.

Hiring

All the personnel in manufacturing, except owners, have been hired at least once. Hiring includes:

(1) *recruiting,*
(2) *selecting,* and
(3) *inducting.*

Recruitment techniques find the people who might want a particular job, Fig. 34-5. If there is more than one qualified *applicant* (job seeker), techniques are used to *select* (choose) the best worker. After the worker is selected, he must be *inducted.* That means he needs to be told what his work is. He also needs to know how he should do his work. He needs to know where he can get lunch or safety equipment. He needs to know what to do if he gets hurt or needs to rest. Thus inducting means telling him all the many things he needs to know to do his work and to satisfy his personal needs.

Hiring practices have to work. This means that the techniques used to recruit, select, and induct must work. Recruitment techniques must get the information about job openings to the applicants for them. Selection techniques must help to *reject* (turn down) job applicants who will not do well. However, employers must be careful so that their selection techniques do not *discriminate* against particular kinds of applicants. According to federal law, an employer may not refuse to hire a person because of his race, sex, color, religion, or national origin. In addition, many states have laws which prohibit these kinds of discrimination plus some others (age, for example). Induction techniques must help workers adjust to their new jobs. They must also keep them from making unnecessary mistakes. Effective personnel departments have studied hiring practices. They know which techniques work and which do not.

Training

If manufacturing changes more rapidly every year, then workers must change too. They must learn new knowledge and skills. If they do not, they may become *obsolete* (out-of-date) along with the machines they work with. Most large manufacturing companies today have training programs. These programs are planned, organized, and controlled to give all workers the training they need. This training is given to both production workers and to management personnel.

Training is given in different ways. Some firms have complete schools which look much like the school you are in. Others simply have training department workers. They arrange for workers to be trained off the job. They find out what training certain workers need and who gives it. Then they make arrangements so the training can be given to the workers. This training may be by public or private schools or even by other companies. Another kind of training is given to some workers on the job. It is done by brief lectures, demonstrations, or closed circuit television. Sometimes workers are coached while they do the jobs they were hired for, Fig. 34-6.

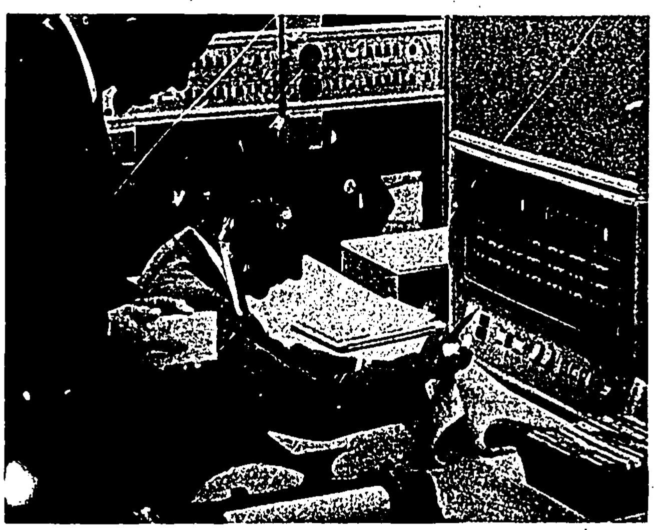


Fig. 34-6. Most management and many technical jobs need people with advanced training. College degrees are often needed.

There will be greater need in the future for further education and training for all workers. Even people with advanced graduate training in a university must keep up with the rapid changes in manufacturing. Industrial training departments must see that workers get new knowledge and skills.

Working

The conditions under which employees work are set by rules. When a *trade union* has organized the workers in a plant, these rules are arrived at through a process known as *collective bargaining*. Workers, through their representatives, are then able to share in the process of making the rules under which they work. When no union is involved, the employer usually makes all the rules by himself.

The rules under which employees work usually can be divided into three groups:

(1) *wages*,
(2) *hours*, and
(3) *working conditions*

Most people know what wages and hours are. "Wages" are the money a worker gets for his work. "Hours" refer to the amount of time a worker must work. Usually, the work day is eight hours long. Thus a worker normally works 40 hours a week (5 days x 8 hours). If an employer wants a worker to work more than 40 hours in one week, he must pay him *overtime*.

"Working conditions" are not as generally well understood as wages and hours. This term refers to all of the *fringe benefits* (such as vacation with pay, retirement programs, health programs, etc.) which workers may have, plus such things as coffee breaks, rest room facilities, lighting, and those other things which relate to the physical conditions under which an employee works, Figs. 34-7 and 34-8. Working conditions are just as important as wages and hours. For example, it might be that both the amount of money a job pays and the hours of work are above average. But, if the job is very dangerous, many people might not want to work at that job. Similarly, if the working conditions are very good, workers might be willing to accept lower wages than they might ordinarily demand. Of course, workers and their unions try to *maximize* (get as much of) both wages and working conditions when they bargain with their employer, but often they are not able to do so and must trade some advantage for some disadvantage.

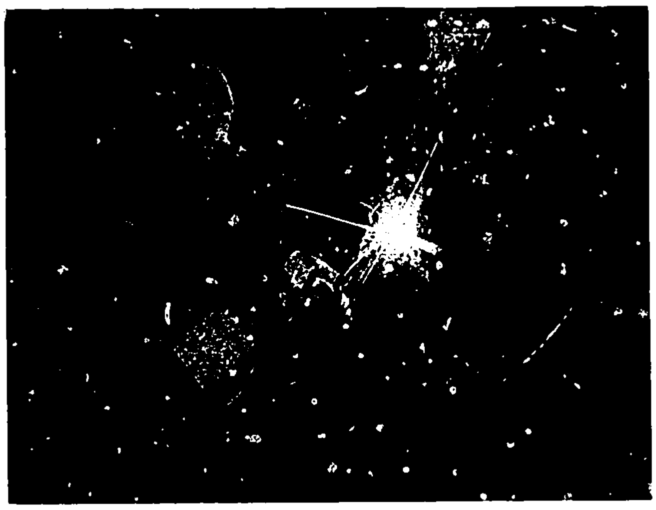


Fig. 34-7. Personnel departments are often in charge of setting up and maintaining safe working conditions. Proper equipment must be given to the workers.

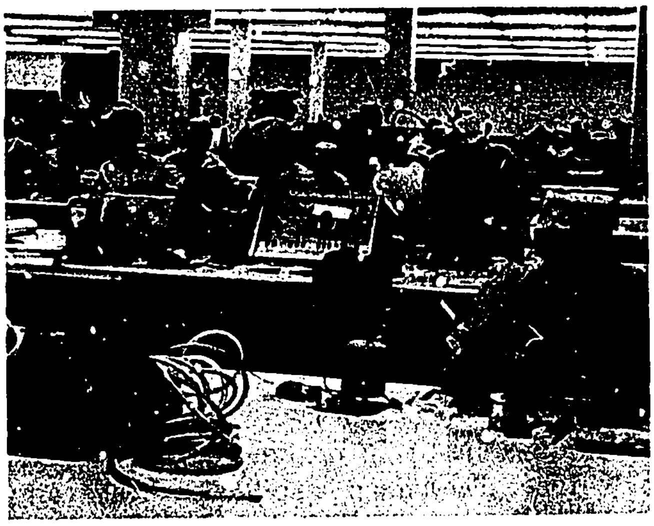


Fig. 34-8. Working conditions in this air conditioned, dust-free room help the product as well as the workers.

Advancing and Retiring

Advancement techniques change the jobs of people by *promoting* them (moving them upward), Fig. 34-9. They also may *demote* (move downward) people who do not do their work well. Another kind of advancement may be *lateral* (along the present job level). People may wish to work with other people or in other departments. It could be an advancement to move to a similar job in another location.

Retirement may be thought of as a special form of advancement, a kind of permanent advancement to a nonworking position. People who retire may continue to receive wages and other benefits. Both advancement and retirement techniques are important to workers, so they must be used well if workers are going to benefit from them, Fig. 34-10.

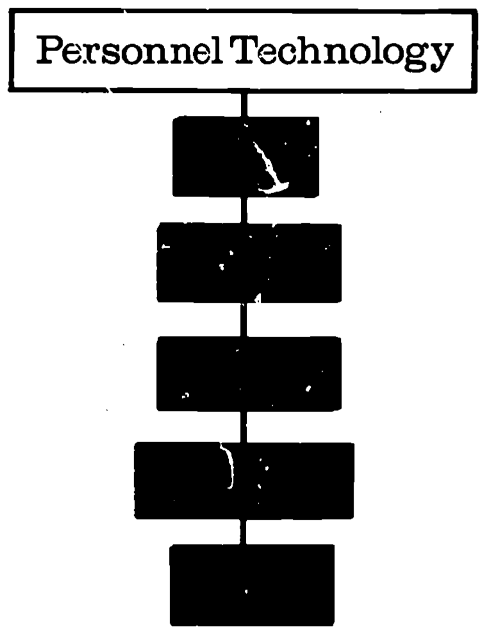
Summary

Industry affects the lives of everyone in many ways. Industrial workers are directly influenced by industrial personnel technology. People are a very important resource. This makes the techniques which are used to hire, train, work, advance, and retire them very important. Personnel technology helps to get an efficient work force, and it helps people to continue working efficiently.

The ability of machines to do work may be predicted very accurately. They work according to their designer's plan. The ability of people to do work can be predicted less accurately. Even if it is known what they can do, they may not do it if they are unwilling. People cannot be turned on and off like machines. With good personnel techniques, people will work better and with greater personal satisfaction.

Fig. 34-9. Production workers are often promoted to positions as foremen or supervisors. Workers look forward to promotions based on good work.

Fig. 34-10. More thought is given to retirement than in past years. A hobby often gives a man physical activity as well as a small income.



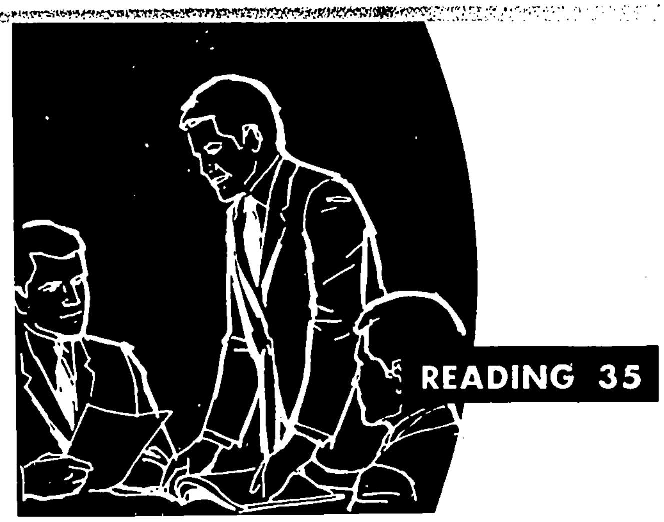
Terms to Know

surpluses
industrial workers
personnel technology
practices
hired
trained
worked
recruitment
applicant
select
inducted
reject
discriminate
obsolete
trade union
collective bargaining
wages
advanced
retired
hiring practices
working conditions
advancement
retirement
planned
organized
controlled
hiring
  a. recruiting
  b. selecting
  c. inducting
hours
overtime
fringe benefits
maximize
promoting
demote
lateral
qualified
rules
regulations

Think About It!

1. How should a worker be selected for a job if there are several *qualified* applicants for that job?
2. What are the *rules* (*regulations*) under which your father works at his job? Are they very much like the ones you have in school?

Hiring and Training



Any company's ability to operate and grow depends on the people it hires and trains. Most companies have *systematic* (planned) programs of hiring and training. You will learn about *hiring* and *training* in this reading. Reading 36 will present three other phases of manufacturing personnel technology: working, advancing, and retiring.

Hiring Practices

The duties of the personnel department are: (1) to *recruit* people who want work, (2) to *select* the best qualified people, and (3) to *induct* them into the work force. In large companies *personnel specialists* may work at these jobs full time. In small companies several people may work at these jobs in addition to their regular jobs.

Recruiting

No matter how large or small the personnel staff is, *recruiting* usually starts inside the company. Well trained people may have certain jobs but may wish to work on another job that is now open. *Openings* come about by promotion, retirement, or by people leaving the company for other work.

Companies often use a system of *job posting*. Openings are listed on bulletin boards or in company newspapers, Fig. 35-1. Workers who are interested in these jobs may then apply for them.

Any opening within a company often means that new people from outside the company will be needed. Employers use several sources. These include public and private employment agencies, schools (Fig. 35-2), colleges and universities, newspaper ads,

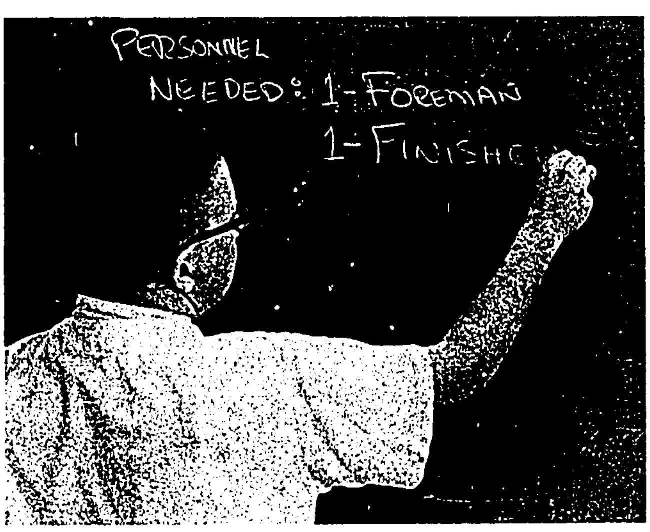


Fig. 35-1. This is job posting. An employment department employee lists job openings on a bulletin board.

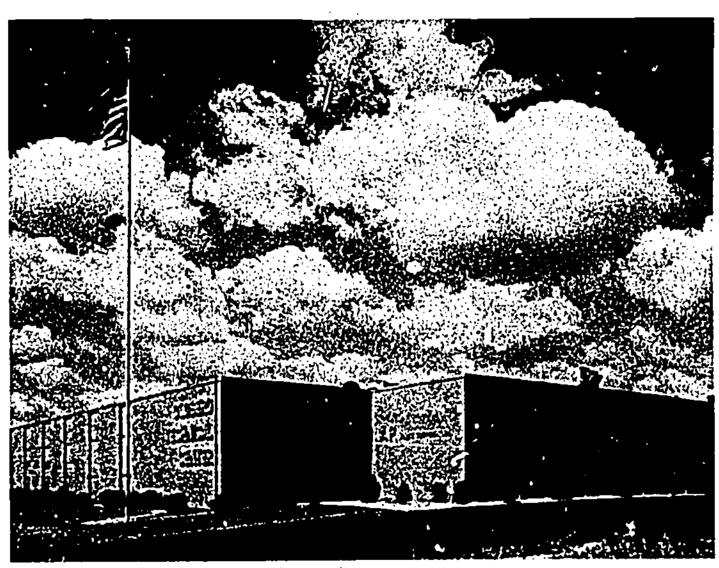


Fig. 35-2. Employment department personnel sometimes visit schools to try to recruit workers.

or other firms which are reducing their work force.

Selecting

The first contact between *prospective* (probable) workers and companies is through an application form. An *applicant* (person applying for a job) should complete this form as carefully and accurately as he can. How well he does this makes an important first impression.

First, employers study all the applications they get. There will be some applicants who seem to have some of the basic *qualifications* (training, schooling, and experience) for the jobs. These applicants may be asked to take a series of tests. The test scores are used to *evaluate* (judge) further the skills and background of the applicant. These tests measure simple things like how well a person can use his hands or fingers. Other tests tell how mechanically minded an applicant is. Special *aptitude* (ability), intelligence, interest, and many other personal qualities are measured through such tests.

The personal *interview* plays the most important part in selecting the right person for the job. Here the applicant's personal appearance, manners, and interest enter into the final selection. After this interview, each applicant is compared with others who are applying for the job. A further check is made for those who seem to be the best ones for the job. A complete check is made of *public records, school transcripts* (records), and records of past employment, Fig. 35-3.

The final step in selection may be a complete physical examination, Fig. 35-4. This may be done by the company if it has its own medical facilities, or an arrangement is made with a doctor outside the company. Of course, during this process of recruiting and selecting, an employer must make certain that he does not *discriminate* because of race, color, national origin, sex, or religion. If he does, he is guilty of violating the law.

Fig. 35-3. A complete check is made of public records, school transcripts, and past employment records of all applicants who may be able to fill a job opening.

Fig. 35-4. A complete physical examination is required by many companies before they hire people.

Inducting

Hiring includes several inducting practices. A formal *appointment* (notice of employment) is often written. For some top-level management jobs, moving costs may be *reimbursed* (paid back). Personnel records are set up and placed on file in the *personnel* (employment) *office*. For some jobs, records of past employment are sent to the right departments.

When the worker first reports for work, there are formal or informal *work-orientation* (introduction) sessions for him. The supervisor of the new worker tries to answer the questions he may have. The new worker gets this help until he feels comfortable and sure on his job.

Training Practices

The earlier education and training of the new worker give him the *basic skills* he needs to start work. Without basic skills a worker may not have much chance to get the job in the first place. But no matter how good or complete his schooling or experience may have been, there are bound to be some things he did not learn in school or on other jobs. Different employers will want the jobs done in different ways.

What are some of the ways that companies train people? There are many. You will learn about a few here.

Fig. 35-5. Sometimes a supervisor gives on-the-job training to a new employee.

On-the-job Training

Most of the training done in industry is *on-the-job training*. It has many advantages. One important advantage is that there is only one new worker for each teacher, Fig. 35-5. The teacher, or supervisor, can give all of his efforts to that one person. Also, the new worker has to learn how to do only one kind of job. All his effort can be put into learning one set of skills. For example, if the worker is to learn how to run a certain machine, he is taught on that machine. Another advantage is that he learns from doing real work. He is actually learning to do what he is going to be paid to do.

There are two disadvantages to this method. First, on-the-job training often takes a lot of time. The teacher is usually an experienced worker who knows how to do the job. Industry trains him to teach. But often he cannot be a full-time teacher. He has his own work to do. Lack of teacher time leads to another disadvantage. Without full-time help, it is easy for the worker to learn the wrong thing.

Vestibule Schools

Large companies sometimes set up a school for training workers. These *vestibule schools* are not in the production area. The new workers learn on a machine, but not one used in production. They can learn more thoroughly and at a slower pace. They are well trained before they go to a production area. Vestibule schools use teachers who

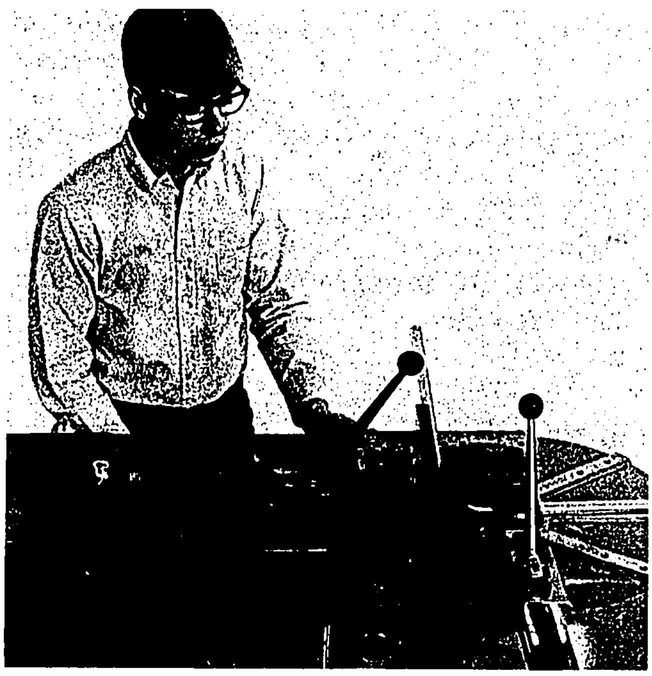


Fig. 35-6. Apprentice training is open to many young qualified individuals.

have been specially trained for industrial training work. Only large companies can do this kind of training. It costs a lot to buy machines which are not used for production.

Apprenticeship

The oldest kind of training is *apprenticeship*. Apprentice training is used to teach people how to do very skilled and complicated work such as toolmaking, plumbing, or electrical work, Fig. 35-6. It may take a period of about four years to learn the skills of the trade. The apprentice spends part of his time in on-the-job training and part of his time in classrooms. His classroom work includes courses in industrial mathematics and science.

Classroom Training

Classroom training in industry is very much like classroom teaching in your school. People who know a lot about a certain field of study are the teachers. The students are workers who must master a subject so that they can do a job well. The teacher lectures, demonstrates, leads discussions, and shows motion pictures or slides. The subject may be topics like new automatic installations or laws about taxes and paying bills.

The length of the class sessions and the course depends on many things. It will differ from company to company. Since the workers are away from their jobs, the classes are usually not held for long periods of time. The course may last one or two sessions, or it may last several months.

Cooperative Training

Cooperative training means that a college or a school will work with a company to educate new workers. The new worker goes to school full-time for a definite period. Then he goes back to work. How long he is in school depends on the college he attends. Many colleges have ten-week periods.

In order for a cooperative program to work best, the job must fit the education and the education must fit the job. The cooperative student must be able to see how his work fits into his education. Earning money is *not* the main purpose of cooperative education. The worker does get paid, but the main purpose of this plan is to make his education give more meaning to his work.

Presupervisor, Supervisor, and Executive Training

People have to learn how to *manage* (direct) the work of other people. You do not wake up one morning and find that you are a good leader. Managing other people's work depends on skills and knowledge which can be learned.

Industry spends a great deal of time and money training people how to lead others. Sometimes these people are sent to universities for *seminars* (research and study). They may attend classes inside the company.

The teachers for these classes may come from inside the company or they may be university professors.

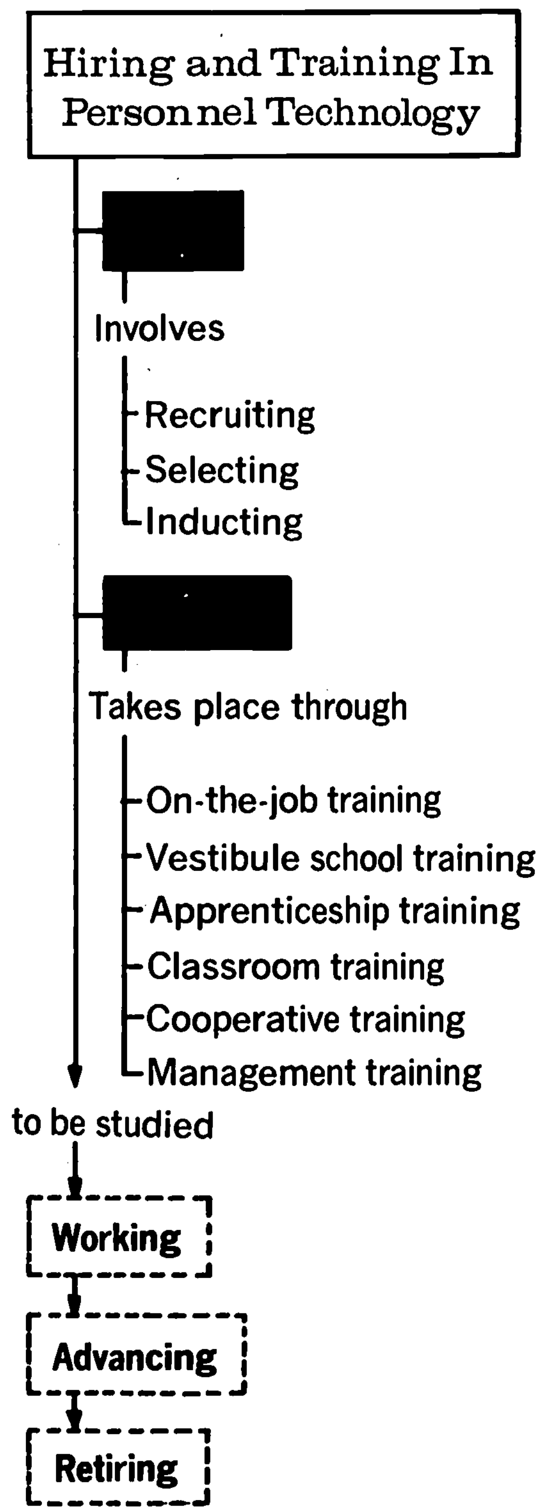
Workers learning to be supervisors may take courses in time study, work methods, human relations, and how to teach. Those learning to become better managers study such things as budget control, company organization, and psychology.

Summary

People are an important resource in manufacturing. To make sure of growth, personnel departments have learned to use efficient ways of hiring and training new workers. Hiring and training are two important parts of manufacturing personnel technology.

The main jobs of hiring are recruiting, selecting, and inducting. Training may be done on the job, in special classes, or in outside schools or colleges. Workers at all levels continue their education and training while at work, Fig. 35-7. Training costs the company money, but it is an investment in future growth.

Fig. 35-7. Managers must keep up with new events. No one ever outgrows his need for education.



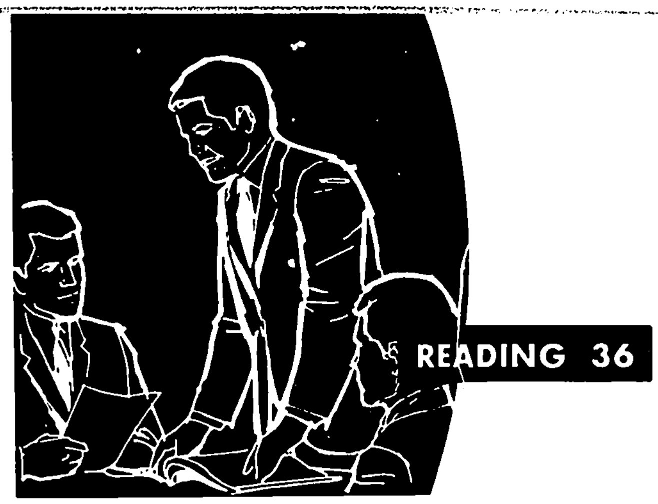
Terms to Know

systematic
hiring
training
recruiting
selecting
inducting
personnel specialists
openings
appointment
reimbursed
personnel office
work-orientation
basic skills
on-the-job training
vestibule schools
apprenticeship
job posting
prospective
applicant
qualifications
evaluate
aptitude
interview
public records
school transcripts
discriminate
classroom training
cooperative training
manage
seminars

Think About It!

1. Why do employers want to look at your *school transcripts* and *records of your past employment* when they are thinking of hiring you?
2. Why does industry spend a great deal of time and money training people to be supervisors and executives?

Working, Advancing and Retiring



Manufacturing personnel technology is the knowledge used by industry to get and keep a work force. It includes five main steps. These are:

1. Hiring,
2. Training,
3. Working,
4. Advancing, and
5. Retiring.

Hiring and training were studied in Reading 35. You will learn about the last three steps of *working*, *advancing*, and *retiring* in this reading.

Working

The first purpose in designing a factory was to produce goods. Buildings and machines were all that the factory owner used to think he needed to set up a factory. He thought that good management meant getting the most labor for the least cost. Even the workers never thought to ask for improvements or comforts. *Competition* for jobs was great. Thus, workers knew that they were taking *risks* (chances) when they took a job. The worst working conditions were in the *sweatshops*. These were uncomfortable, dirty rooms in which people worked long hours for very low wages. Almost all employees, including women and children, worked twelve hours a day for six days a week. Disease and accidents were common. A worker was not paid when he was not able to work.

Conditions were so bad that the government finally had to step in. Laws were passed regulating the employment of women and children. The *National Labor Relations Act,*

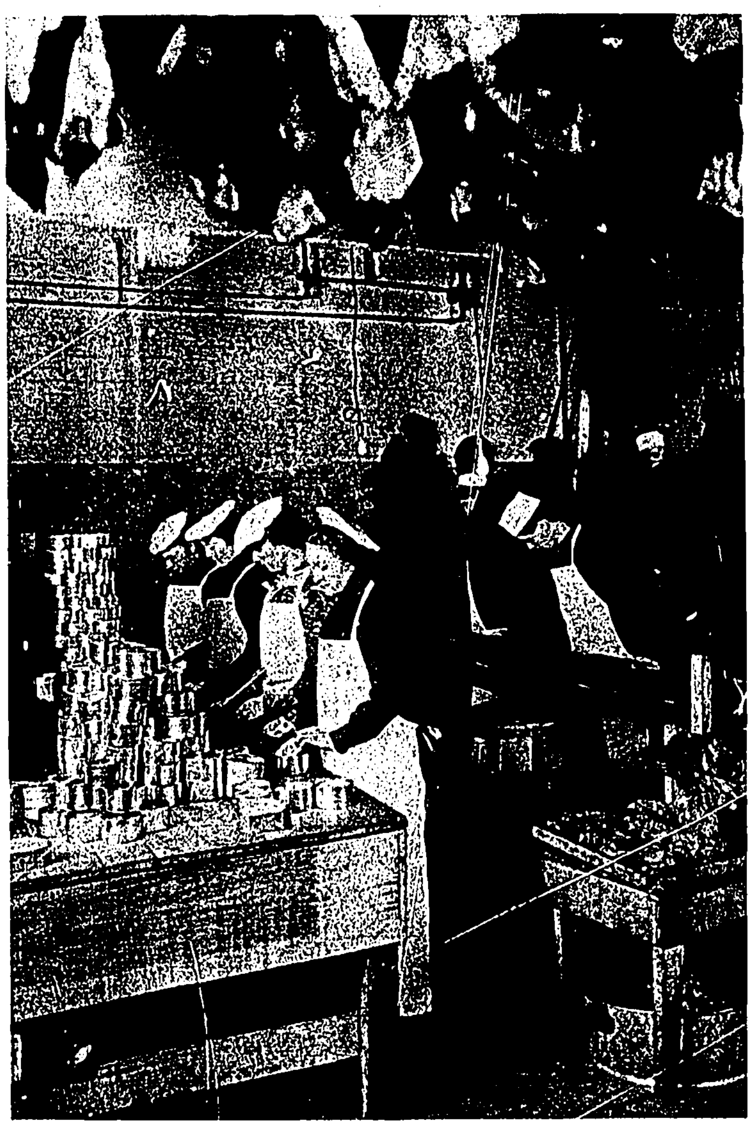


Fig. 36-1. Compared to present-day standards, early factories were poorly lighted, unsanitary, and poorly laid out. Improved equipment, building design, and management knowledge have been applied to our modern plants to improve working conditions. The factory shown above, however, was considered modern, adequately lighted, and well-equipped at that time by governmental standards.

which became a law in 1935, was most important. This law forced employers to *bargain* with the labor unions which represented workers. Once employers began to bargain with unions, many changes took place in the plant. Employers agreed to better physical conditions in which to work, Fig. 36-2. They also agreed to such things as rest periods, coffee breaks, and regular lunch periods, Fig. 36-3. These things helped to raise a worker's productivity by relaxing and resting him and thus helped the employer as well.

Of course, many employers did these things without the help of the unions. Thousands of workers in manufacturing are not represented by unions. Some states, such as Texas, have *right-to-work* laws. An employee does not have to become a member of a labor union, even if the union bargains for all employees. Other state and federal laws have helped to improve working conditions. These laws affect such things as hours of work, overtime, and minimum wages.

One of the most important things that unions bargained for was a *grievance procedure*. This procedure is designed to help solve those problems that arise in a modern industrial plant. When a worker has a complaint or *grievance*, he discusses this problem with a union official called a *shop steward*. This official has been chosen by other workers to represent them in these situations. He will examine the grievance and decide if it is *legitimate* (reasonable). In order to know that, he must understand the *contract* (agreement) which the union and the employer have *negotiated* (bargained for). If the worker's complaint is reasonable, then there was either a misunderstanding or a breaking of the contract by the employer.

Usually, the shop steward will try to resolve the grievance by discussing it with the company official who supervises the worker who made the complaint. If no solution is found, the union may take the grievance to higher levels in the procedure, either to higher company officials or, finally, to an *arbitrator* who makes a final decision in the case.

Fig. 36-2. Today factories are well-lighted, clean, and well-equipped.

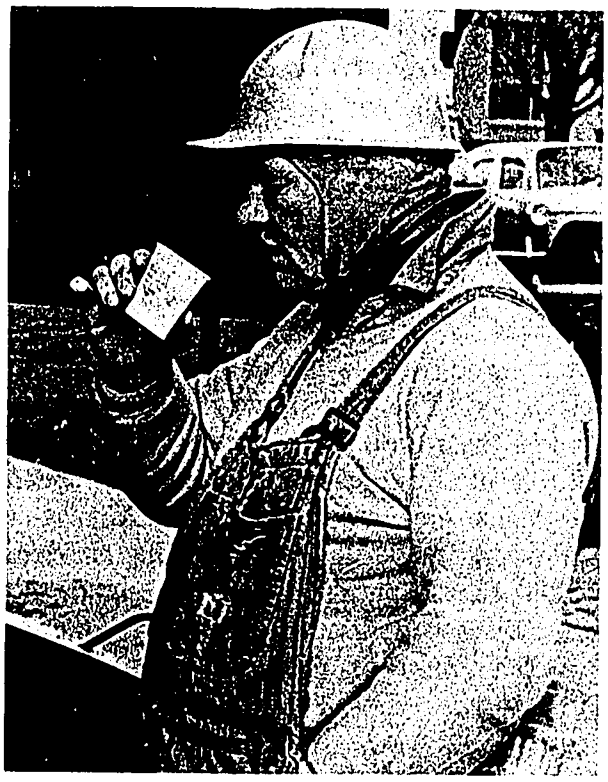


Fig. 36-3. Here a worker is taking a break from his job.

Thus, the grievance procedure can be outlined as follows:

1. Grievance.
2. First level of appeal (usually to workers' supervisor.)
3. Second/third levels of appeal (to higher company officials).
4. Arbitration (binding on all parties).

It is important to remember that the grievance may be settled as early in the procedure as the second step. If that happens, then further appeals are not necessary.

The grievance procedure is important for several reasons. *First*, it insures that the contract will not be broken or misunderstood. *Second*, it gives the workers a feeling of helping to make important decisions in the plant. *Third*, it allows these kinds of problems to be solved without the use of a *strike*. If there were no grievance procedure, the only thing workers could do if they did not like an employer's decision would be to refuse to work, or strike. This would be bad for both employers and workers since both would lose money if work was stopped. Thus, the grievance procedure helps everyone.

Good work settings also give economic rewards to the worker. The *wage* is payment that is made by the day, hour, or unit-piece of work. A *salary* is payment made by the month or the year. Wages and salaries are usually paid in money. Sometimes they may be paid in goods. A worker might get free *rent* or a *discount* (reduction of price) on products as a partial payment for his work. He might also get shares of *stock* in the company he works for. In addition to wages and salaries, workers also get *fringe benefits*. Among these are extra pay for working night shifts and holidays, jury duty pay, insurance benefits, vacation pay, and cost of living changes in pay rates.

Some of the most valuable benefits a worker receives come to him through either the federal government or from the government of the state in which he lives. When he retires he receives *Social Security* payments from the Social Security Administration of the United States government. If he is injured at work, he receives *Workmen's Compensation* benefits, and if he becomes unemployed, he receives *unemployment compensation* until he finds another job. These may be paid for, in the form of taxes, by both the employee and the employer, or paid entirely by taxes on the employer.

Advancing

In industry, chances for *advancement* (moving up) are greater than ever. Advancement of valuable employees is necessary to expand, modernize, and control the production system. The size and complexity of these modern manufacturing plants are increasing. Companies need more trained people to manage their production processes. It is very hard for an average worker to become a manager or supervisor. The worker may be very good at his own job; however, he may not have the training he needs to become a supervisor or manager. Therefore, in this way, it is getting harder for the average worker to advance.

Workers may be *promoted* (moved up) to jobs that need more physical and mental skills. Also, supervisors and managers are promoted up the management ladder. Many workers and unions have wanted men to be promoted because of their *seniority*. This means that the worker who has been employed in the plant for the longest time and who has the most experience will get the promotion. It also means that employers cannot fire or transfer older workers so that these older workers can be replaced with younger, stronger workers. In this way a worker who has worked for an employer a long time is protected.

Sometimes workers are never promoted. They may not do their jobs well enough. They may not have the skills they need for their job. They may not have the interest (*motivation*) to work well. It may even be necessary to *demote* them (move them downward) to a lower-level job. Employers often do not like to demote workers. Often they

have *counseling services* (talking things over) to help the worker with personal problems that may be bothering him, Fig. 36-4. They may also have *retraining programs* to help him improve his skills. However, some workers go on doing their jobs so poorly that they must be *discharged* (fired).

Workers who do their jobs well may also be *laid off* (temporarily discharged). This happens in *seasonal* industries such as the fruit-canning industry. It also happens in industries that have many changes in the product, such as automobile manufacturing. These workers get *unemployment insurance payments* until they find another job or are called back to their regular job.

Retiring

Every worker must retire some day, so he should make plans for his retirement. He usually has either *social security insurance* or a company *pension plan* to support him and his family after retirement, Fig. 36-5.

Employers usually want the retiring worker to feel worthwhile. They often hold some kind of a ceremony to reward his service to the company. A gift such as a watch, may be given to him at a dinner in his honor. Announcements of this event may appear in the plant and local newspapers. All this is done to make the worker glad that he is getting a well deserved rest, Fig. 36-6.

Fig. 36-5. This skilled machinist will retire this year. He has a retirement plan with his company that will give him and his family retirement payments, medical care, and insurance.

Fig. 36-4. An employee may talk with management about his problems.

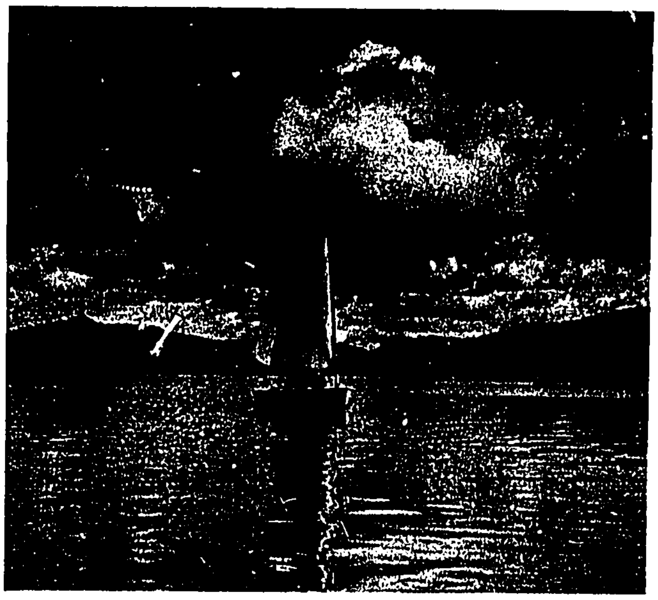


Fig. 36-6. After they retire, people have more time to spend on their favorite hobby or sport.

A worker may continue to be paid after he retires. Retirement payments may be made to him regularly. They are often made to his family after his death. Certain fringe benefits such as insurance and medical care are also given to him and his family. Sometimes a retired worker does not feel ready to take it easy. He may go on working part-time. Usually, he can go on collecting his retirement benefits if he works part-time after retiring.

Summary

Working, advancing, and retiring all help to get efficient workers for manufacturers. Ways to carry out these activities must work well for both labor and management. There are problems, however, for both labor and management. Labor knows what it wants and needs. Management knows what is possible and how it may be put into practice. So there must be close cooperation between labor and management in personnel technology.

Terms to Know

working
advancing
retiring
competition
risks
sweatshops
National Labor Relations Act
bargain
right-to-work law
grievance procedure
rent
discount
stock
fringe benefits
Social Security
Workmen's Compensation
unemployment compensation
advancement
grievance
shop steward
legitimate
contract
negotiated
arbitrator
strike
wage
salary
promoted
seniority
motivation
demote
counseling services
retraining programs
discharged
laid off
seasonal
unemployment insurance payments
social security insurance
pension plan

Working, Advancing, and Retiring In Personnel Technology

- You have just studied
  - Hiring
  - Training
- [illegible]
  - Providing economic rewards
  - Providing physical setting
  - Providing social environment
- [illegible]
  - Promoting
  - Demoting
  - Discharging
- [illegible]
  - Counseling
  - Preretirement job engineering
  - Recognizing service
  - Awarding retirement benefits

Think About It!

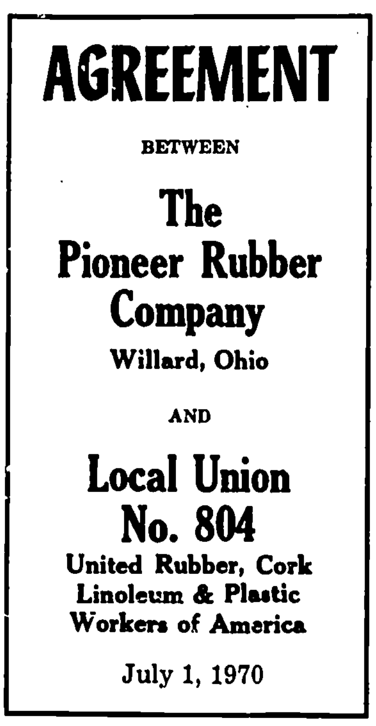
1. Why do you think the *sweatshop* conditions described in this reading are no longer true in industry today?
2. Why do rest periods and coffee-breaks make workers do better on their jobs?

Organized Labor and Collective Bargaining

People used to think that each worker had the right of *freedom of contract.* He could agree to work for an employer under certain conditions, or he could refuse to do so. He could quit a job and take another. He could make high wages if he could do a job better than other workers. For most workers these freedoms did not really exist. If there were very few jobs he could get, a worker often had to take a job with poor working conditions or keep one he did not like. If there were many workers, then he had to take low wages or be replaced by someone else. So, groups of workers organized to protect the freedoms and rights of the individual worker. These organizations are called *unions.*

Most industrial workers do not belong to a union. Union members now make up about one-third of all industrial workers and one-fourth of the total working force in America.

In those companies where unions do exist, unions and employers *negotiate* (talk over and exchange ideas) to reach *agreements (contracts).* Contracts set up wage rates, working conditions, and other benefits. Agreements or contracts usually cover a period of time from one to three years, Figs. 37-1 to 37-6.


AGREEMENT

BETWEEN

The Pioneer Rubber Company

Willard, Ohio

AND

Local Union No. 804

United Rubber, Cork Linoleum & Plastic Workers of America

July 1, 1970

Fig. 37-1. This book contains the agreement (contract) negotiated by a union and a company involved.

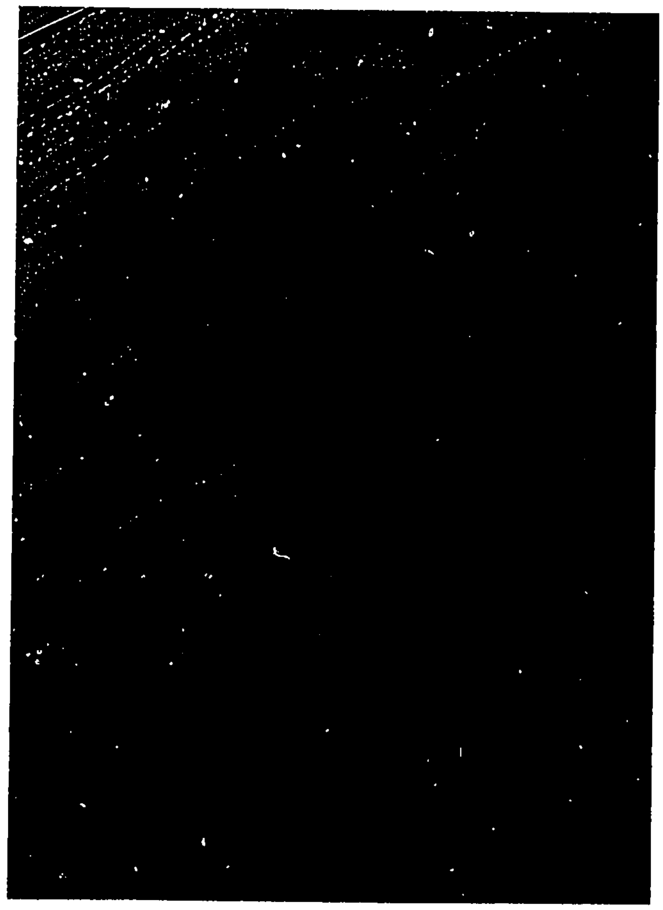


Fig. 37-2. The first part of an agreement states the limits of the contract.

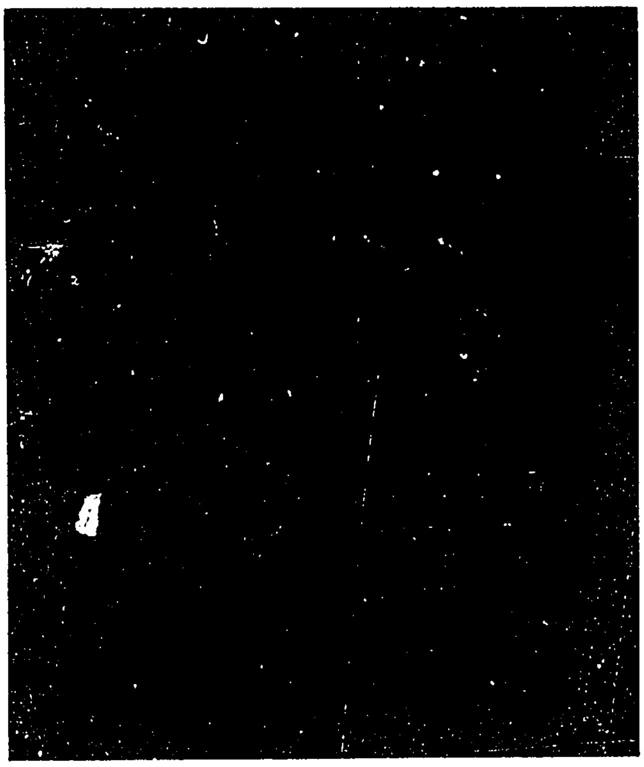


Fig. 37-3. After the introduction, the various areas agreed on in the contract are listed.

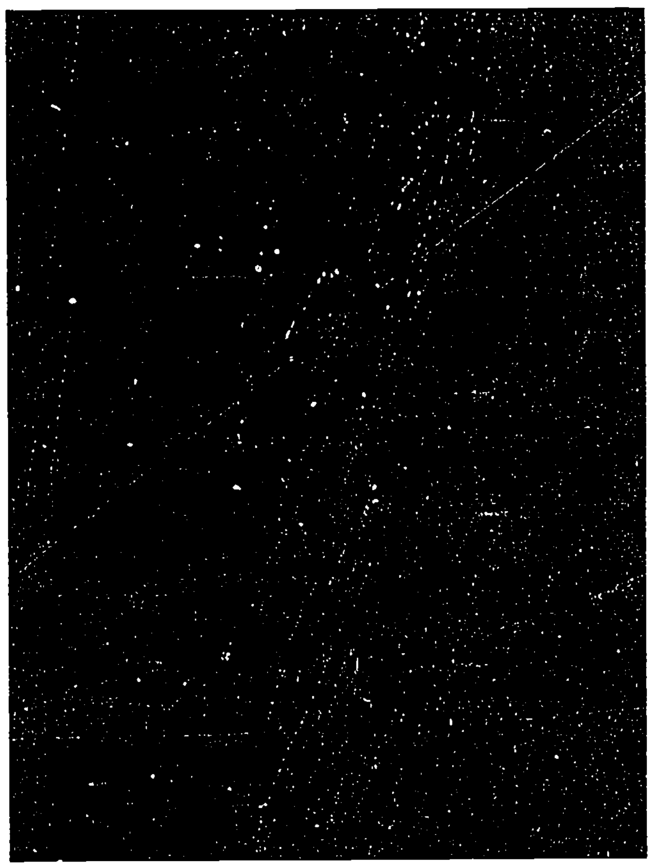


Fig. 37-4. *Wage Appendix A* lists the hourly rate of the lowest paid workers covered by the contract.

History of Organized Labor

Labor unions began to develop in the United States shortly after the Revolutionary War. The first such organization was formed in 1792 by shoemakers in Philadelphia. In 1794, New York City printers organized a permanent "Typographical Society." In 1827, fifteen such *locals* joined together to form the Philadelphia Mechanics Union of Trade Associations. This was the first time that union locals involved in different trades joined to make a *city central body* such as we have today. In 1834, delegates from all of the city federations met in New York City to form a *national federation* similar to the *AFL-CIO* of today. They called their first national organization the National Trades Union.

About this time, local unions from the same trade began to develop national organizations. The first of these, the National Typographical Society, an organization of printers, was organized in 1835. Although it soon went out of existence, it was reorganized in 1852 and still exists today.

After the Civil War, the first great federation of unions was organized. *The Knights of Labor* began in 1869 in Philadelphia when a few garment workers organized a local. At the height of its power, in 1886, it had a membership of over 700,000. The Knights believed in *arbitration* instead of *strikes,* in a shorter work day, in producer and consumer *cooperatives,* and in the organization of all workers into one big union.

At the same time the Knights were growing, the national trade unions were growing also. These organizations believed that only workers in the same trade should belong to the same organization. This is called *craft unionism.* According to this belief, all printers would be in one national union (made up of many locals in different cities), all shoemakers would be in another union, all carpenters in another, and so on. The leaders of these unions did not believe that all workers should be in one organization. So,

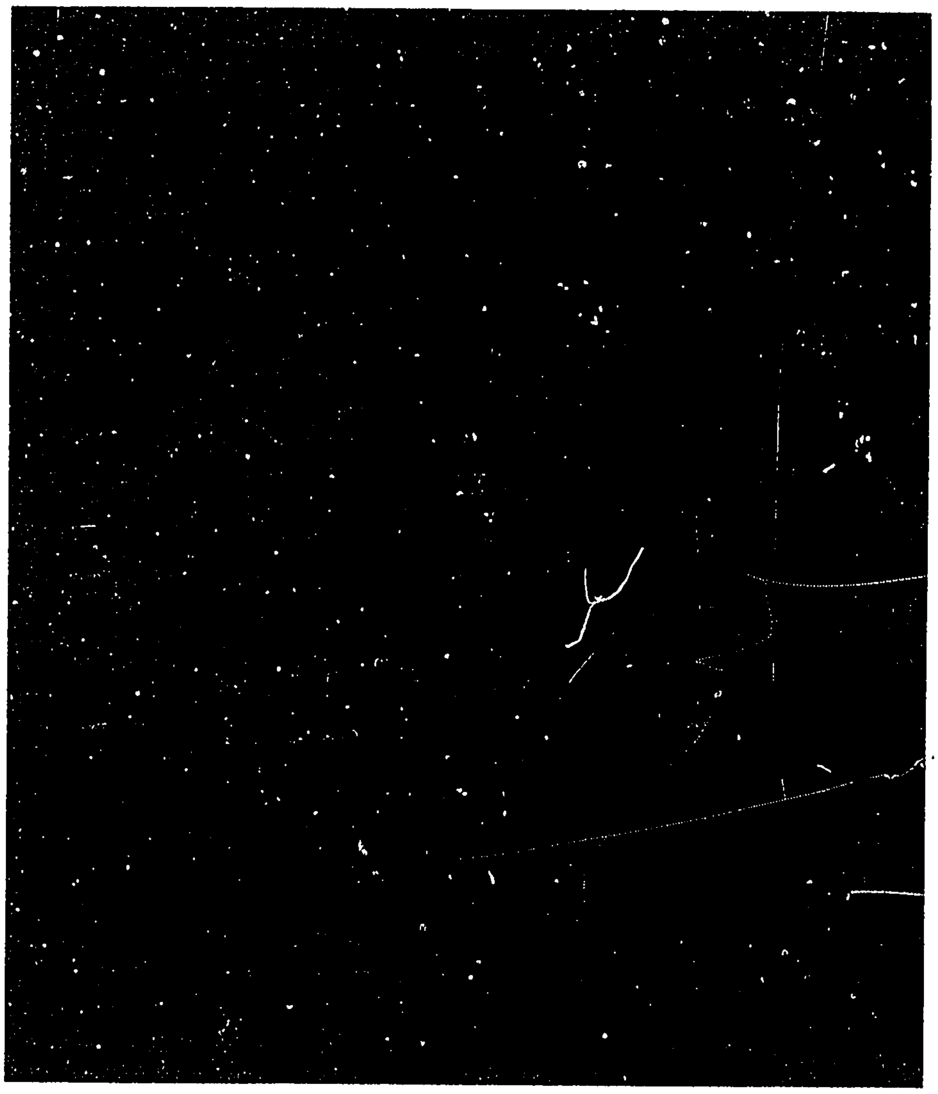


Fig. 37-5. As employees work their way up to skilled jobs, they earn more money.

in order to oppose the beliefs of the Knights of Labor, these national unions formed the *American Federation of Labor (AFL)* in 1886.

At the time when the AFL was formed, much of the work performed in America was of a craft nature. Although the first factory had been in existence for many years, it was not until after the Civil War that the great industrial plants began to develop. Even when they did, the idea of separate crafts had been part of American labor's beliefs for such a long time that it was hard to change. Even though methods of production changed so that more and more work was done by *unskilled* factory workers instead of *skilled* craftsmen, many unions failed to change their ideas about organization. It was not until the depression of the 1930's that the first *industrial unions* were formed. In these unions, workers who worked in the same industry (such as steel manufacturing, auto manufacturing, etc.) would belong to the same national union made up of many locals. In 1936, these industrial unions formed the *Congress of Industrial Organizations (CIO)*. In 1954, these two great federations merged to form the *American Federation of Labor-Congress of Industrial Organizations (AFL-CIO)*. Since that time several national unions, such as the *Teamsters*, the *United Mineworkers*, and the *United Automobile Workers (UAW)* have left the AFL-CIO. In 1969, the Teamsters and the UAW formed the *Alliance for Labor Action (ALA)*.

These federations of national unions are organized to help labor conduct political and educational activity. Each major city has a

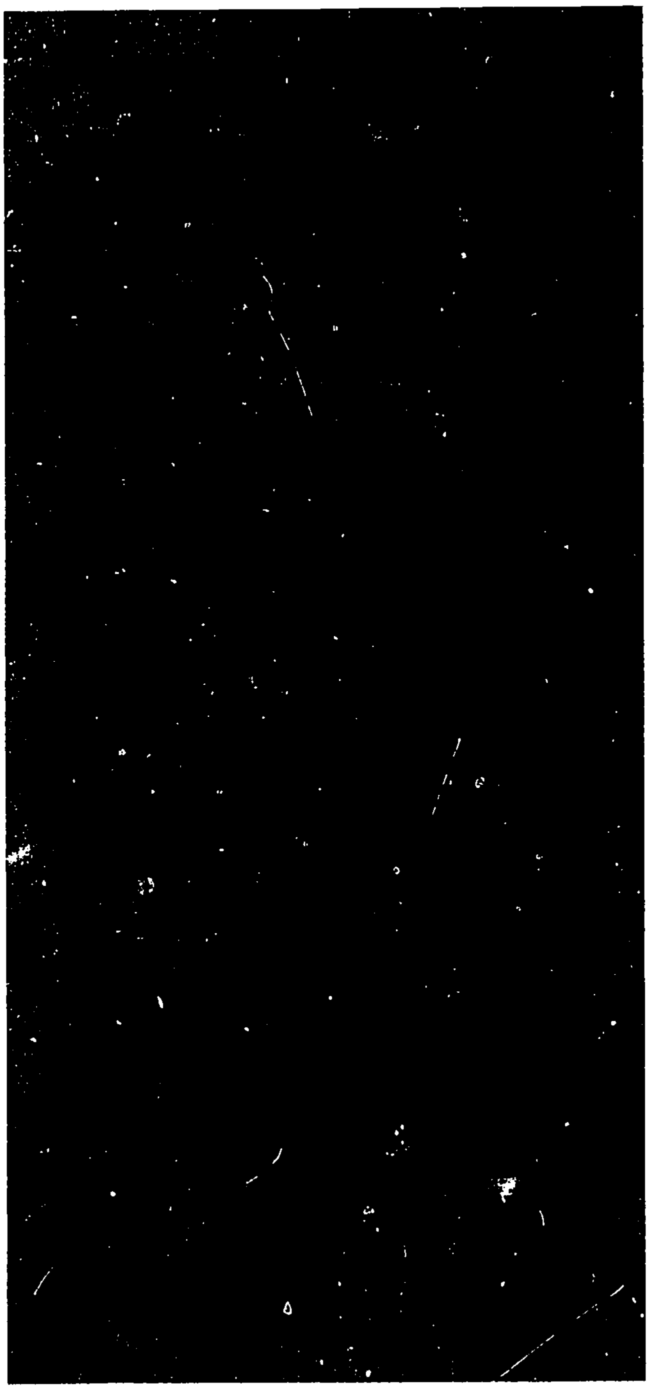


Fig. 37-6. Most contracts spell out how a grievance will be handled.

local *AFL-CIO Central Body*. All of the locals of the national unions in the AFL-CIO in each city belong to the local central body. Also, each state has a *state AFL-CIO* made up of all of the local central bodies in the state. These local and state federations endorse political candidates, conduct education programs, publish newspapers, and conduct other activities of a political and educational nature. This is only part of the work that unions do, however. Much union work is conducted by the national unions themselves when they enter into *collective bargaining* with the employers in their industry or craft.

Collective Bargaining

Although collective bargaining began in the late 19th century, it was not until 1935, when Congress passed the *National Labor Relations Act* (*Wagner Act*), that it became a reality for great masses of workers. In passing this law, Congress realized that great harm is done to the economy when employers refuse to recognize a union as the representative of their workers. Many strikes or work stoppages resulted from this refusal and in a period of economic depression, such as the 1930's, these strikes worked even more economic hardship than they would today. Therefore, the Wagner Act made it illegal for an employer to refuse to bargain with a union representing his workers.

Before the Wagner Act was passed, employers did many things to keep from recognizing unions. Sometimes they would get *injunctions* against workers, forbidding them to *picket* or march in protest against an employer's refusal to recognize a union. Sometimes they would hire other workers, called *scabs*, to replace striking workers. Other times they would make workers sign *yellow-dog contracts* in which a worker would promise that he would not join a union in return for a job. Employers used detectives as spies to report what the workers were doing. As soon as employers had to recognize unions, however, most of these practices disappeared.

During this period, the employers said that they would talk with individual workers about their problems, but that they would not talk to outsiders (a union) concerning these problems. The workers said that one man alone was not strong enough to win any

arguments with an employer and that only through joining into a union could they achieve their goals. Congress recognized the truth in the workers' belief when they passed the Wagner Act.

Once an employer has recognized a union as the representative of the workers, men from both sides enter into collective bargaining or talks in an attempt to *negotiate a contract,* Fig. 37-7. This means that representatives from both sides sit down together and listen to each other's ideas about how a plant should be run. They may talk about how much money workers should get, how long they should work, what kind of safety equipment the company should provide, and any other item that deals with wages, hours, or working conditions in the plant. Sometimes unions say that the employer should bargain about a particular subject and the employer does not agree and refuses to talk about it. If the union really believes that this subject is important, it can appeal to the *National Labor Relations Board* in Washington. This Board decides all of the questions concerning the relationships between an employer, his workers, and the union which represents those workers.

If the employer and the union cannot reach agreement about the contract after they have honestly tried to, the workers may hold a meeting and conduct a *strike vote.* If the workers are not willing to accept the contract that the employer offers, they may refuse to work until they are satisfied. Before the workers refuse, however, they take a vote and the majority decides whether or not they will strike.

Instead of striking, unions and workers may make use of *mediation* services. Here, a mediator meets with representatives from both parties and tries to help them reach a solution. His suggestions are not binding on either party but, since he is *neutral,* each side will take his advice in many cases. However, if they still do not agree, a strike will result.

When workers strike, they are fighting their employer economically. That is, they believe that if their employer is stopped from doing business, he will agree to their terms. In the same way, the employer believes that if the workers are forced to go without wages they will agree to his terms. Many times, after a strike, the agreement reached is somewhere between the offers the employer and the union made. Thus, each gains and each loses from the strike.

Summary

Most workers in manufacturing do not belong to a labor union. Union members now make up about one-third of all industrial

Fig. 37-7. Management and union representatives discuss their labor problems.

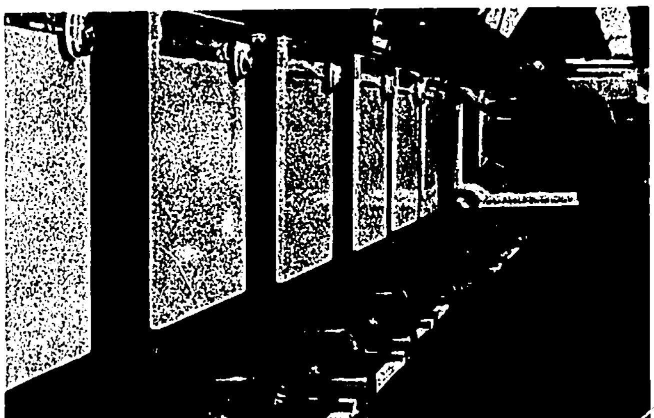
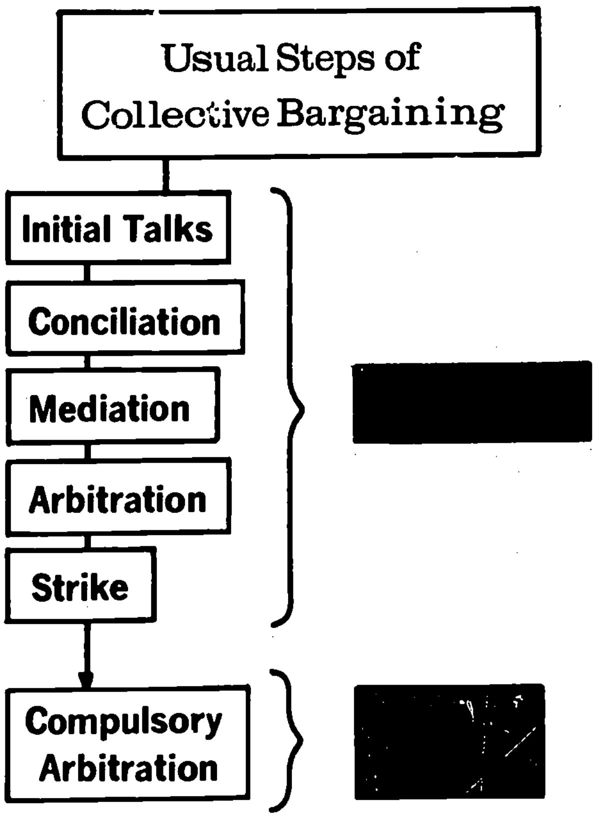


Fig. 37-8. Job standards on assembly lines are often negotiated by management and the union. This assembly line is producing dishwashers.

workers and one-fourth of the total working force in America. In some states, union membership is far below the national average. Many workers have organized into groups called labor unions. These unions sometimes use strikes to achieve workers' demands. However, they know that collective bargaining is less costly to both labor and management. Often, labor and management work together to avoid strikes completely, Fig. 37-8. In so doing, they go through a series of steps which will finally produce a settlement. These steps are:

1. Union Proposal
2. Management Counterproposal
3. Negotiations
4. Conciliation/Mediation
5. Strike

It is important to remember that a settlement may be reached as early as Step 3 (Negotiations). If it is, a strike is unnecessary. Also, even when workers strike, they continue to negotiate for a settlement. The strike is used to pressure the employer into agreeing to the union's proposals.



Terms to Know

freedom of contract
unions
negotiate
agreements
contracts
locals
city central body
national federation
AFL-CIO
The Knights of Labor
arbitration
strikes
cooperatives
craft unionism
American Federation of Labor (AFL)
unskilled
skilled
industrial unions
Congress of Industrial Organizations (CIO)
AFL-CIO
Teamsters
United Mineworkers
United Automobile Workers (UAW)
Alliance for Labor Action (ALA)
AFL-CIO Central Body
state AFL-CIO
collective bargaining
- a. union proposal
- b. management counter-proposal
- c. negotiations
- d. conciliation/mediation
- e. strike

National Labor Relations Act (Wagner Act)
injunctions
picket
scabs
yellow-dog contracts
negotiate a contract
National Labor Relations Board
strike vote
mediation
neutral

Think About It!

1. If both labor and management know that strikes and long disputes are costly to both sides, why do you think that strikes and long disputes still happen?
2. Explain what is meant by collective bargaining, and list three factors that may be involved in bargaining.

READING 38

Securing Reproducible Raw Materials

All raw materials used in manufacturing come from nature in one form or another. Before these materials can be used, they must be taken from their natural state in the air, earth, or water. In this reading, you will learn about ways of getting *reproducible* raw materials.

Source—Plants and Animals

Reproducible raw materials come from plants and animals. Man has used plants and animals since the earliest time. Man must have food, clothes, and shelter for himself and his family. All the time available to all the people can be thought of as a kind of resource. Only the time left over after getting food, clothes, and shelter can be spent doing other things.

Machines are a product of industrial technology. They have given more time to people, as a group. Also, fewer people are needed to raise plants and animals, so more people can work in industry. Each farm worker supplied ten people with food and clothing in 1930. In 1970, each farm worker supplied 46 people.

Some plants and animals are found in a wild state. Others are raised by ranchers, farmers, gardeners, and orchardists. The lumbering industry raises and cuts down trees, either from a forest or from tree farms, Fig. 38-1. The fishing industry gets fish and other marine life from the oceans, rivers, and lakes. Hunters and trappers hunt wild animals for hides, fur, and meat, Fig. 38-2.

Need for Conservation

Every living thing has basic needs. These needs are water, food, the right tempera-

Fig. 38-1. A tree cutter completes an undercut on an oak tree in a forest in the northwestern United States.

Fig. 38-2. These fur buyers are looking over fur pelts from fox, mink, squirrel, muskrat, and Persian lamb.

ture, and protection from natural enemies. All the needs of a plant or animal are met by its natural *environment* (surroundings). Forest fires, soil *erosion* (wearing away), and water *pollution* (making dirty or impure) destroy the natural environment for thousands of *species* (kinds) of living things. These natural and man-made forces take away large amounts of plant and animal life every year.

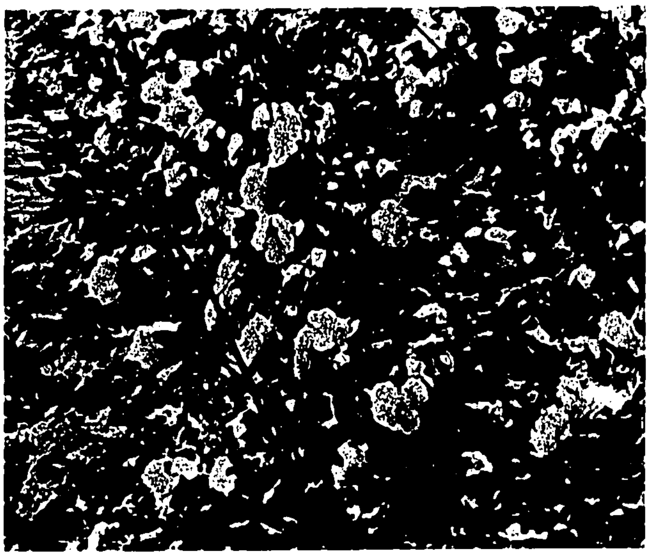


Fig. 38-3. This field of cotton is ready to be harvested. The crop is ripe and at its best.

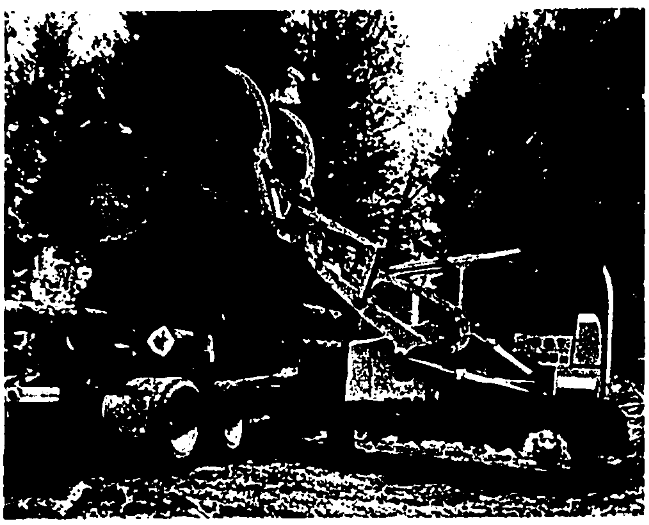


Fig. 38-4. A loader tractor is loading cut timber onto a truck. It will then be moved to the storage area at a processing plant.

It takes a long time to get rid of poisons in lakes and rivers. Nature cannot grow a new forest in a man's lifetime. Lost topsoil cannot be completely replaced. So, men must *conserve* (protect) nature's resources of land and water. They must also conserve enough *parent stock* so that every useful species of plant and animal will be reproduced for future use. Farmers, ranchers, hunters, fishermen, and loggers all must try to stop the loss of forests, soil, and wildlife which could never be replaced. Programs of *reforestation* (replanting) and other *conservation programs* are very important.

Harvesting must be done during the season when a crop is ripe, Fig. 38-3. But it must always be done in ways to conserve the environment and the parent plants. If not, there will be no crops during the next growing season.

Securing Crops

Harvesting is the process of collecting whole plants or plant parts for some use. Farmers raise and harvest many different plants for food and fiber for clothing. Many grains are harvested for their seeds: for example, wheat, corn, and rice. The rest of the plant is either returned to the soil or made into animal feed and other products. Vegetables are harvested for their roots (carrots), leaves (lettuce), or flower (cauliflower). Other vegetables are harvested for their tubers (potatoes), stems (rhubarb), or oil (mint). Sugar maple and rubber trees are tapped for their sap. Fruit is picked from trees, vines, and bushes.

Migrant workers follow the harvest season from south to north. They pick fruits and vegetables by hand. Crops are cut by machines operated by farmers.

The actual process of harvesting includes cutting, digging, picking, peeling, or tapping. Men usually want to get the crop at its best. The harvested crop must be moved to market, to storage, or to a *processing* (preparing) *plant*, Figs. 38-4 and 38-5. The

buyer wants the crop to be *uniform* (all the same quality), attractive, healthy and cheap.

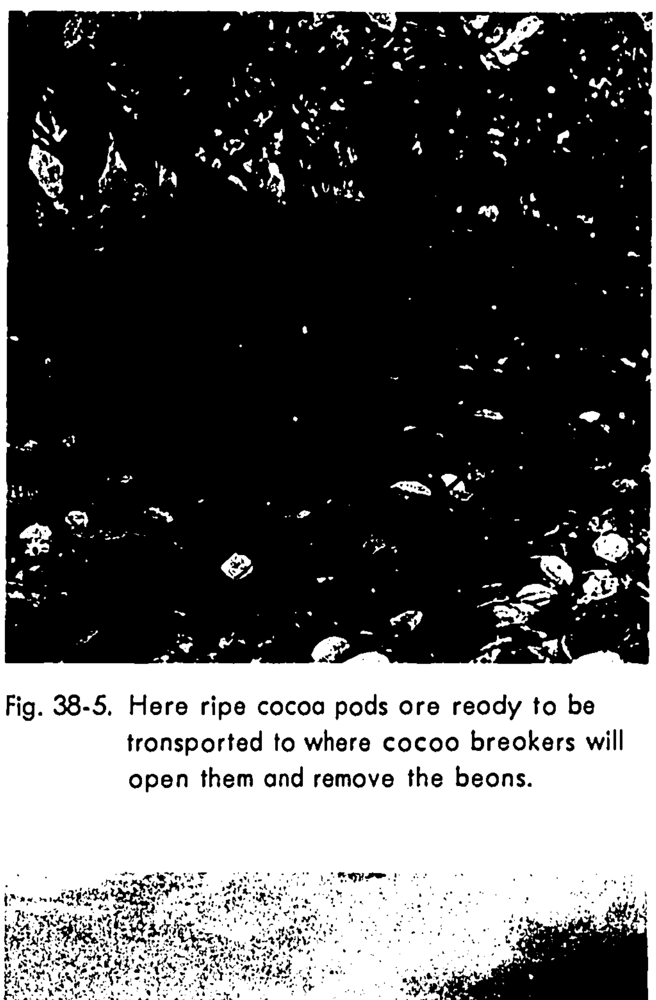


Fig. 38-5. Here ripe cocoa pods are ready to be transported to where cocoa breakers will open them and remove the beans.

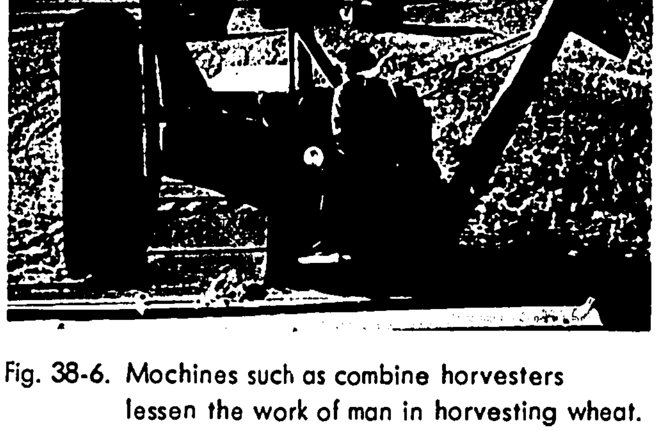


Fig. 38-6. Machines such as combine harvesters lessen the work of man in harvesting wheat.

One large manufacturing company contracts with farmers to produce green peas. Its fieldmen oversee planting, *fertilizing* (improving the soil), and *spraying* (against disease and insects). At harvest time, the company's crews bring harvesting machines and trucks to a farm. The crews work fast since the peas must be canned within four hours after picking. Some of the farms may be 75 miles from the cannery.

Much progress has been made in the design and manufacture of special harvest machines. This has cut the cost of harvesting and ended some of the hardest work. Imagine a machine which picks only the ripe strawberries! Compare the hand sickle with today's one-man combine harvester, Fig. 38-6. Some combine harvesters have operators' cabs with air conditioning, tinted glass, and two-way radios.

Harvesting takes place at the end of the growing season for many crops. This depends on the crop, the climate, and local weather. Some plants grow more than one crop during the growing season. Growing seasons differ in length in different parts of the country. Local weather sometimes delays planting time which, in turn, shortens the growing season.

The quality of a growing crop depends on local weather conditions and on what the farmer does. Harvesting should be done so that the crop reaches the processing plant at its best quality. Peaches and pears need different methods than wheat and cotton. All crops need the best of care.

Securing Livestock Products

Livestock, dairy products, and poultry are important sources of food and other raw materials. Protein from animals is important to human diets. Leather and wool are better than *synthetic* (man-made) materials for many uses.

Milk is the raw material of the dairy farm, Fig. 38-7. In America most milk comes from cattle. Milk is a healthful drink. It is also

used to make cheese, butter, and ice cream. A dairy cow is killed for meat only when it no longer produces milk. Young male calves are fed for several weeks or months. Then they are *slaughtered* (killed) as veal calves or fattened steers. Only a few select bulls are kept for breeding purposes.

Dairy farmers milk their cows in very clean barns. The milk is stored in refrigerated tanks. Refrigerated tank trucks bring the milk to the processing plants. *Sanitary* (clean) conditions are very important on dairy farms. Inspectors check each farm regularly. Milk samples are checked by technicians at the processing plant. Cows are tested and vaccinated regularly by *veterinarians* (animal doctors).

Beef cattle are bred to produce meat. They are specially fed to get the best quality of meat. The same is true for swine and sheep. Wool from sheep also gives fiber for cloth, Fig. 38-8.

Ranchers keep *foundation herds* of their best beef cattle, sheep, or swine. Foundation herds are made up of the better females and the best males for the purpose of improving the *offspring* (young animals). The best offspring are used to replace animals in the herd. Others are fattened and killed. Ranchers and feedlot operators may sell their fattened livestock directly to packing plants, at livestock auction markets, or to buyers on the ranch, Fig. 38-9. They decide to sell when

Fig. 38-8. Sheep are raised mainly for the wool they produce each year.

Fig. 38-7. Milk from cows is the raw material for a great many food products.

Fig. 38-9. Many feedlot operators raise thousands of head of cattle at one time.

they think the livestock will bring the best price. The livestock buyer will give a price which he hopes will make a profit for his company.

Once bought, animals are slaughtered and processed in a packing plant. *Slaughtering* is the process of killing and dressing animals. In the packing plant, animals are stunned so that death will be painless. Most states say that the flesh and organs must be inspected for disease. The hides, hoofs, and some other parts are separated. The *carcasses* (bodies) may be sent to butcher shops. They may also be processed in the packing plants for retail food markets. *Butchering* is the process of cutting the carcass into parts. Some pork meat is *cured* (by smoking or other processes) to make hams and bacon.

Nearly every part of the animal is used. Packing-plant workers say, "We save everything but the squeal." By-products include leather, bristles, fertilizer, pet food, sausage casings, and gelatin.

Some poultrymen manage as many as 100,000 laying hens. The hens are often kept in cages where they are fed and watered automatically. Eggs are gathered daily, often by automatic *conveyers*. The eggs are cleaned, *candled* (tested for freshness), weighed, graded, and rushed into cold storage or to retail food markets. Many eggs go into by-products such as noodles.

Most rooster chicks are raised only until they are large enough to serve man's food needs. Like hens, they are often kept in large numbers. They are kept in separate cages and fed scientifically prepared feed mixtures.

Securing Fish and Marine Life

Getting fish and *marine* (sea) life includes seeking, catching, netting, trapping, or gathering. Some scientists think that marine life will be a major source of human food as the world population grows.

Commercial fishermen work from boats specially equipped to catch and handle fish and marine life. For example, salmon are caught in Alaskan waters by trolling. A troll boat is equipped with poles, lines, and gurdies. A *gurdy* is a power reel for pulling in lines or nets. The fish are caught, dressed, iced, and taken to canneries or shipping points.

Other salmon, on their way to *spawn* (deposit eggs) in rivers and streams, are caught by seine fishermen, Fig. 38-10. A *seine* is a large net. Some salmon fishing practices have been stopped because very few salmon were reaching the spawning beds to lay their eggs. The parent stock had to be conserved so that the species would be reproduced.

Other kinds of fish are caught by other methods. Sometimes larger boats, bigger crews, longer stays at sea, long hunts, and processing on board are necessary. Commercial fishing can be exciting, dangerous, and profitable. It can also be slow, boring, and disappointing. Modern fishing boats are equipped with two-way radios, radar, and depth finders.

Fig. 38-10. Purse seining is one method of catching salmon.

Some marine life is gathered or trapped in *beds* on the ocean floors, Fig. 38-11. Oysters are gathered, and crabs are trapped. Some are processed for canning or freezing. Others are shipped fresh, by air freight, to markets on land.

Summary

Reproducible raw materials are gotten by many processes, Fig. 38-12. These processes take plants or animals from land or sea for human use. A crop is processed by methods which best fit the nature of the plant or animal. For the best quality food products, harvesting must be done quickly at the time when the plants are ready. In order to harvest reproducible raw materials, the parent stock and the soil or water which gives life must be conserved.

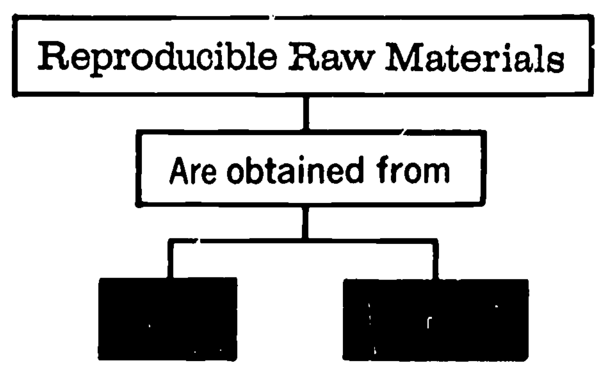


Fig. 38-11. These two fishermen are gathering oysters from beds on the bottom of the ocean.

Fig. 38-12. Bacteria are raised and harvested for drug manufacturers

Terms to Know

reproducible
environment
erosion
pollution
species
conserve
parent stock
reforestation
conservation programs
harvesting
migrant workers
processing plant
uniform
fertilizing
spraying
synthetic
slaughtered
sanitary
veterinarians
foundation herds
offspring
slaughtering
carcasses
butchering
cured
conveyors
candled
marine
gurdy
spawn
seine
beds

Think About It!

1. Why is *conservation* so important in our *harvesting* of *reproducible* raw materials?
2. Why do *you* suppose that *marine* life may be a major source of human food as the world's population continues to grow? Why are air and water *pollution* so dangerous to us *now?*

READING 39

Extracting Raw Materials

In this reading you will learn about the ways man gets nonliving raw materials from nature. These ways are called *extracting.* The raw materials are called *mineral resources.* These raw materials are not like the living raw materials you studied in the last reading. Nonliving raw materials cannot be replaced once they are extracted. This reading tells what kinds of raw materials are extracted, why we extract them, when and where they are extracted, how they are found, and who does the work of extracting.

Kinds of Raw Materials Extracted

There are three main kinds of mineral resources. They are (1) *mineral fuels,* (2) *nonmetallic minerals,* and (3) *metallic minerals. Mineral fuels* include coal, lignite, peat, petroleum, and natural gas. These fuels are now nonliving raw materials, but they came from living things. Partly decayed plants and animals were trapped in *sediments* (layers of fine matter) in the oceans and on land. There are beds of coal, lignite, and peat, and underground pools of liquid petroleum and natural gas. All these materials developed through physical and chemical changes in the trapped plants and animals. These materials are used as fuels. They are also the raw materials used in making many products like plastics, synthetic fibers, and drugs.

Nonmetallic minerals include construction materials like sand, gravel, and building stone. There are also ***abrasive*** (grinding) materials like corundum, and ***insulating*** (protecting) materials like asbestos. Other nonmetallic minerals (gypsum, clay, lime, and sulphur) have many uses in industry.

Metallic minerals are the ores of all the metals, Fig. 39-1. Iron, copper, aluminum, and the other metals are gotten from these raw materials. These metals are widely used in manufacturing.

Reasons for Extracting Raw Materials

Man now makes use of more than 100 different minerals found in nature. We depend on these minerals for making and moving goods and in giving us all kinds of services. Extraction of the raw material is the first step toward the finished product. As man's production grows, the need for raw material grows. The importance of extraction becomes greater.

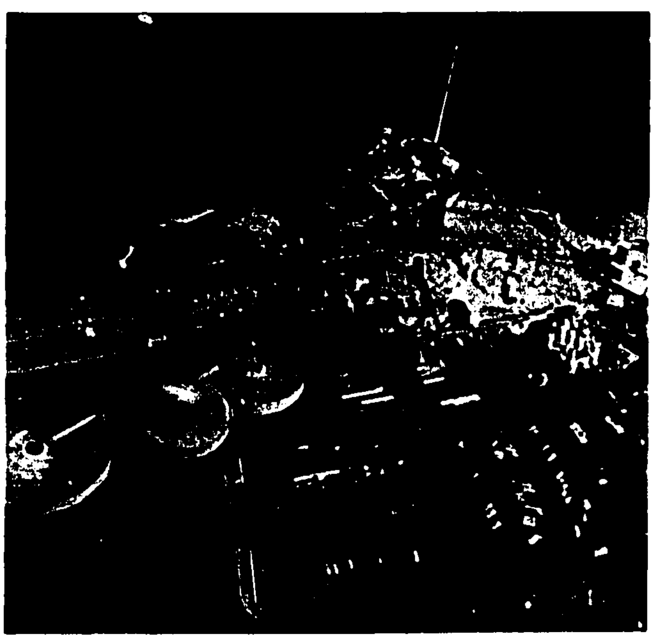


Fig. 39-1. This is an aerial view of a magnesium plant where the metallic material is extracted from sea water.

Where Materials Are Extracted

Mineral resources are not found everywhere in nature. Some areas have a great many minerals. Other areas have very few minerals. Raw materials are found in the air, in the oceans, and in the earth itself. But we can use only those minerals which can be extracted easily. Only nitrogen, oxygen, helium, and some of the rare gases, like neon and argon, can be extracted easily from the air. However, all the elements used as raw materials can be found in the ocean, but only sodium, magnesium, bromine, and a few others can be easily extracted. All others are there in such small amounts that it costs too much to extract them. The world's oceans will become an important future source of many minerals when extraction methods are improved, Fig. 39-2. The solid earth is still our main source of raw materials.

Locating Raw Materials

The job of the *geologist* (who studies the earth's crust) is to find mineral resources. He uses his knowledge of the geological history of an area to tell what mineral resources are likely to be found there. Mineral resources near the surface of the earth are found by a study of the surface rocks. The geologist drills test holes and makes other physical and chemical tests. He can also tell if there is a certain raw material beneath the earth's surface, Fig. 39-3.

Methods of finding minerals depend on the kind of material he is hunting. A *Geiger counter* is useful in finding uranium underground. A study of the earth's magnetism in a certain region might be needed to find iron ore. Along with the geologist, surveyors, engineers, *geophysicists* (who study earth features and the forces that cause them), *geochemists* (who study the chemistry of the earth's crust), and *paleontologists* (who study life of prehistoric time) all help to find raw materials.

When Extraction Is Done

Not all newly found mineral *deposits* (layers or pockets) are extracted. Before extraction, it must be found out if the raw material can be mined at a profit. The shape,

Fig. 39-2. An offshore drilling rig may be used to extract petroleum, natural gas, or sulfur from underneath the sea.

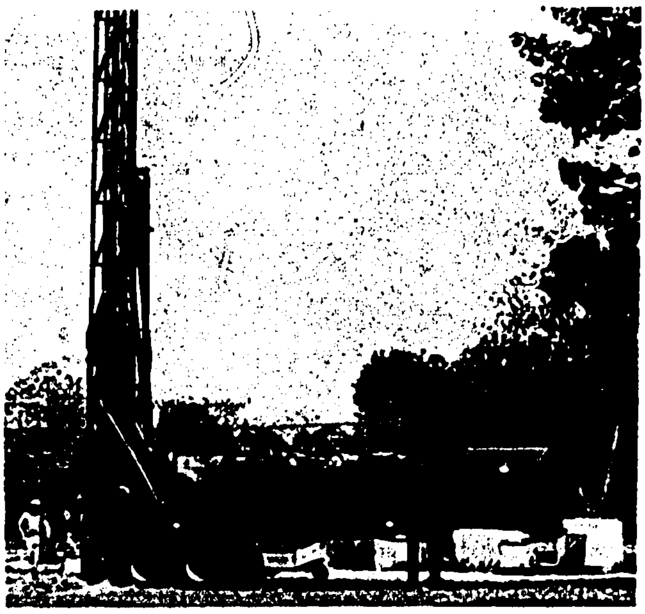


Fig. 39-3. Test holes are drilled to find out if there is a certain raw material beneath the earth's surface.

size, location, depth, and richness of the deposit tell which extraction method must be used to get the raw material. A small deposit deep within the earth or far away from markets might not be mined at a profit. But the same deposit near the surface or near a processing plant could be mined at a profit. Other factors help decide whether to extract a mineral deposit. They include: (1) the nearness of railroads, roads, and pipelines for moving the raw material; (2) the nearness of labor, water, and electricity; and (3) the need for the raw material. Growing needs for a raw material by manufacturers and better, cheaper extraction methods may make some deposits more valuable. A mineral deposit which costs too much to extract now may be cheaper to extract in the future. For instance, the future use of underground nuclear explosions may help in extracting large amounts of oil and natural gas from some kinds of dense rock.

Methods of Extracting Raw Materials

There are three main ways of extraction. They are: (1) *surface mining,* (2) *underground mining,* and (3) *drilling.* In *surface mining* there is a certain amount of rock or soil that lies on top of the deposit (*overburden*). A thin layer of overburden can be taken off by light machines. Thick overburden can be removed by power shovels, Fig. 39-4. It is usually hauled away. Sometimes it is dumped back into the mine after the raw material has been extracted. Sand and other loosely combined raw materials are extracted directly by power shovels. Solid rock must be loosened and broken into usable sizes by blasting or cutting, Fig. 39-5. The extracted materials are loaded into trucks or railroad cars. Then they are moved to storage or to a processing plant.

Small surface mining operations, like small stone quarries, use only a small amount of operating machinery. Stone, like marble, is mined mainly by hand tools, Fig. 39-6, but many metal ores are extracted

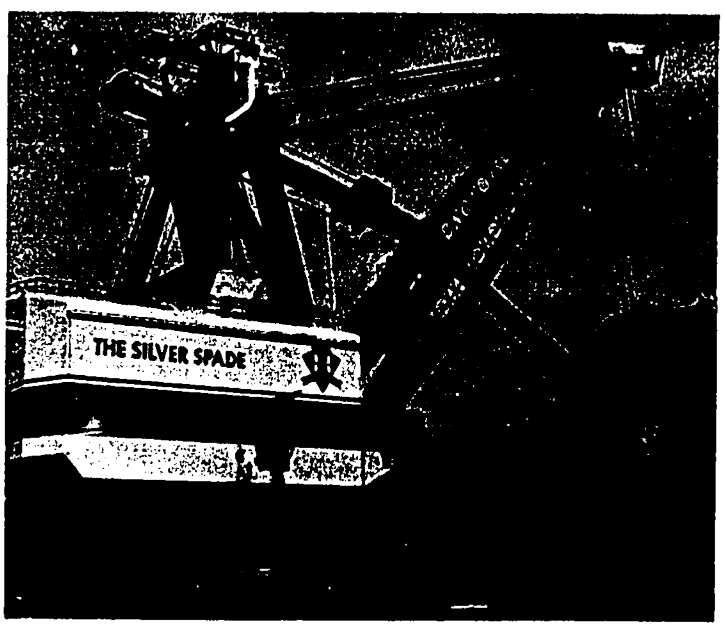


Fig. 39-4. This large power shovel is taking away the overburden to get to a coal seam.

Fig. 39-5. Raw materials, loosened by blasting, are loaded into trucks to be moved to storage or processing.

Fig. 39-6. Marble is quarried in the northeastern part of the United States.

from large surface mines with lots of heavy machines. These mines may be several thousand feet wide and hundreds of feet deep. The walls of large, deep surface mines must be kept from *collapsing* (falling in). For this reason, the ore is extracted in "steps" or terraces to give the walls a safe slope, Fig. 39-7.

Underground mining methods are used when the raw material is too deep to be mined safely or cheaply by surface methods, Figs. 39-8 and 39-9. The deposit is reached by *vertical* or *inclined shafts* or by *horizontal* (level) *tunnels*. Horizontal tunnels are usually drilled or blasted at several levels leading off a vertical shaft. The ore in the roof of the horizontal tunnel is blasted downward, loaded into ore cars, hauled to vertical shafts, and raised to the surface. On the surface, the ore is dumped for storage and further processing.

Vertical mine shafts may go two miles downward. They may have several horizontal levels. Usually, a kind of mining called *room and pillar* is used in extracting the raw material. The deposit is divided into *rooms* separated by *pillars* (supports). The ore or mineral is then extracted from the rooms. The pillars are left to *support* (hold up) the roof. Thus, in underground mining nearly half the raw material may be left as supporting walls and pillars. In surface mining all the raw material can be extracted.

Raw materials like oil or natural gas are found in the *fluid* (liquid) state deep underground. Oil and natural gas are extracted by *drilling*. At one time, all drilling was done by the *cable tool* method. In this kind of drilling, a heavy, wedge-shaped cutting tool was hung from a steel cable. It was then dropped, over and over again, on the material being drilled. After a while the tool was removed. Then a "bailer" was let down to pick up the rock cuttings at the bottom of the hole.

Fig. 39-7. This is an aerial view of an open-pit mine. The terraces or "steps" give the walls a safe slope. This mine is a half-mile long, a quarter-mile wide, and about 250′ deep.

Fig. 39-8. An electrically powered loading machine is filling a shuttle car with potash ore. The shuttle train moves the ore to the mine shaft for hoisting to the surface.

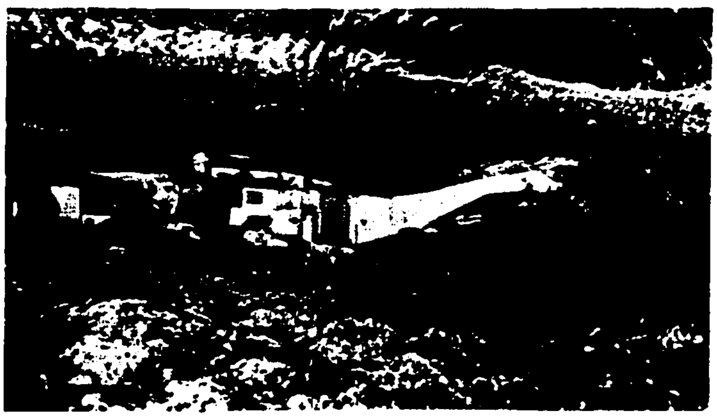


Fig. 39-9. This rotary cutter, continuous-mining machine rips coal out of a seam at four tons per minute. This machine works well in thin coal seams since it is only 36″ high.

Today, most drilling is done by the *rotary* method. A cutting bit is fixed on the end of metal tubing and *rotated* (turned in a circle) at the surface, Fig. 39-10. The bit cuts downward in a hole filled with dense mud. The mud keeps the walls from caving into the hole. It also floats the broken bits of rock to the surface. Steel casing is used to line the hole when drilling is complete. The oil or gas may be as deep as five miles underground. At this depth the steel casing is *perforated* (holes made in it) to let the oil or gas flow inward. The petroleum is then pumped to the surface. There it is stored in large tanks or pumped through pipelines to the refinery for processing, Fig. 39-11.

Salt and sulphur are also extracted by drilling. They are in a solid state underground, so they must be made *fluid* (able to flow) by pumping heated water into the deposit. The hot, melted, or dissolved material is pumped to the surface for storage and processing.

The solid earth is man's main source of mineral deposits. The geologist is in charge of finding new deposits of raw materials. He must also find out the size and nature of a deposit and if it can be mined at a profit.

Fig. 39-10. The bit is being changed on this rotary drilling rig. The rigger is standing on the rotary table.

People Who Work in Extracting

We have read about some of the people who find deposits of raw materials. These people, along with many others, work in the extraction process. Surveyors, drillers, men who work on the drilling rig, pumpers, pipeline layers, and others work in extracting petroleum. Drillers, explosive experts, heavy-machine operators, truck drivers, and others work in mining operations.

Fig. 39-11. A walking beam is pumping oil from its natural underground deposit to a storage tank.

Summary

Nonliving raw materials cannot be reproduced or replaced. Once they are used up, they are gone forever. There are three kinds of mineral resources: (1) mineral fuels, (2) nonmetallic minerals, and (3) metallic minerals. Nearly all materials used in manufacturing processes are included in these three groups.

Minerals are extracted by one of three methods: (1) surface mining, (2) underground mining, or (3) drilling. The method of extraction used depends on the kind, depth, and location of the mineral deposit. Many people, including geologists, engineers, surveyors, drillers, machinery operators, and truck drivers, do the work of extracting.

Classes of Mineral Resources

- [redacted]
- [redacted]
- [redacted]

Terms to Know

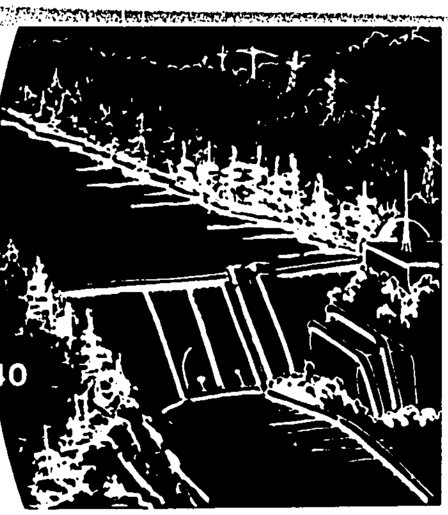
extracting
mineral resources
  a. mineral fuels
  b. nonmetallic minerals
  c. metallic minerals
sediments
abrasive
insulating
geologist
Geiger counter
geophysicists
geochemists
paleontologists
deposits
surface mining
underground mining
drilling
overburden
collapsing
vertical shafts
inclined shafts
horizontal tunnels
room and pillar mining
pillars
rooms
support
fluid
cable tool
rotary
rotated
perforated

Minerals Extracted by

- [redacted]
- [redacted]
- [redacted]

Think About It!

1. What *mineral resources* does your state have?
2. What will happen if man uses up the earth's supply of nonreproducible mineral resources?



READING 40

Harnessing Energy from Nature

Energy is the ability to do work. It is one of the inputs to a manufacturing production system. Nature's energy must be *harnessed* (controlled) in order to be used by man. The kind of energy used in each case is decided by its efficiency and cost, and by how easy it is to use. This reading explains (1) the general kinds of energy, (2) the forms of nature's energy, (3) the ways that man harnesses this energy, and (4) the forms of energy that man hopes to harness in the future.

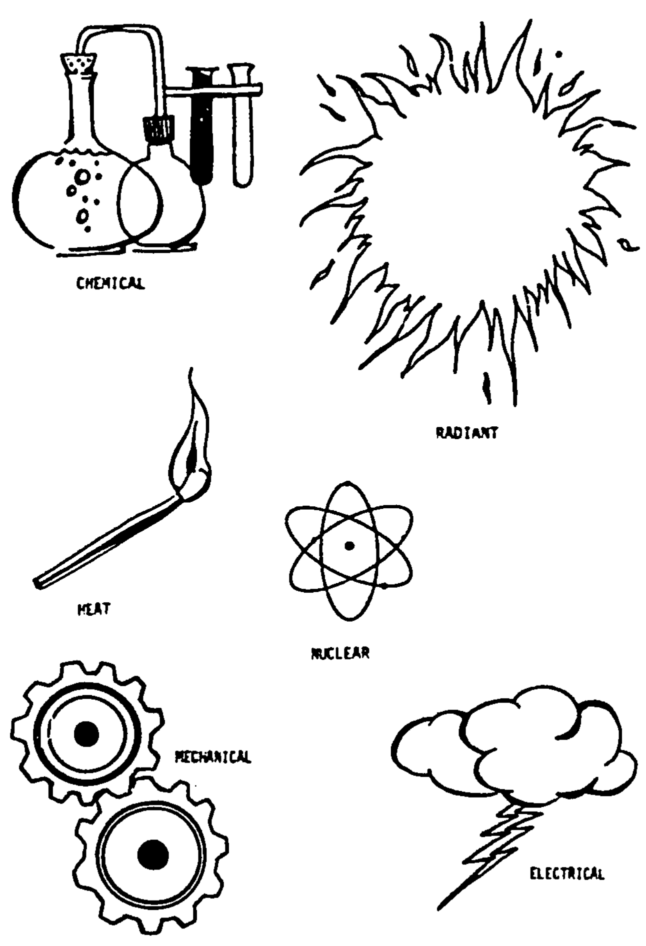


Fig. 40-1. There are six main kinds of energy.

General Classes of Energy

There are six main kinds or classes of energy. They are (1) *mechanical,* (2) *radiant,* (3) *chemical,* (4) *heat,* (5) *electrical,* and (6) *nuclear,* Fig. 40-1. A rotating turbine, a moving piston, and a coiled spring are examples of *mechanical* energy. *Radiant* energy includes light, radio waves, and X rays. *Chemical* energy is stored in the atomic and molecular bonds of food and fuels. *Heat* energy is used for warmth and for changing water to steam. *Electrical* energy can be found in electric currents and magnets. *Nuclear* energy is the most powerful form man can use. It comes from the forces holding together the *nucleus* (center or core) of an atom.

Nature's energy is not destroyed by using it. Instead, it is changed from one form to another. This is one of energy's most important features and explains how energy can be put to work by man.

Nature's Energy

Nature stores and *expends* (uses up) a great deal of energy in many ways. Man is able to use only a small fraction of nature's total store of energy. There is energy man can use in the winds, running water, ocean tides, and radiant energy from the sun. Some of the sun's radiant energy is changed by plants into chemical energy. Some of this chemical energy is then stored in the plants. Some plants are used by man for food. Others die and become *fuels* (coal, oil, gas, or wood) man can use.

Harnessing Nature's Energy

To harness the energy of nature, man must *collect, contain,* and *control* it. Man harnesses energy when he eats food. He uses its stored chemical energy for all the functions of life, like body growth, movement, and reproduction, Fig. 40-2.

Industry and government harness many forms of nature's energy. Sometimes it is used directly to manufacture products and give services. Sometimes it is changed to other, more useful forms of energy, Fig. 40-3. A wide range of devices, from windmills to atomic reactors, can be used for harnessing nature's energy.

Harnessing the Energy of the Wind

Early man used only his own muscle power and the muscle power of tamed animals to do his work. The simple task of eating helped him to put the stored chemical energy of food to work.

To help him with his work, early man used the great energy of the winds. Winds are moving air masses. Air moves because land and water take in the radiant energy of the sun at different rates. Air also moves because of the earth's rotation and the local *topography* (land features).

Windmills have been used for centuries. They change the wind's energy into mechanical energy for driving machines to grind grain and pump water, Fig. 40-4.

Fig. 40-2. The eating of plants and animals was man's first way of harnessing nature's energy.

Fig. 40-3. Heat, electrical, and mechanical energy are harnessed in this airplane.

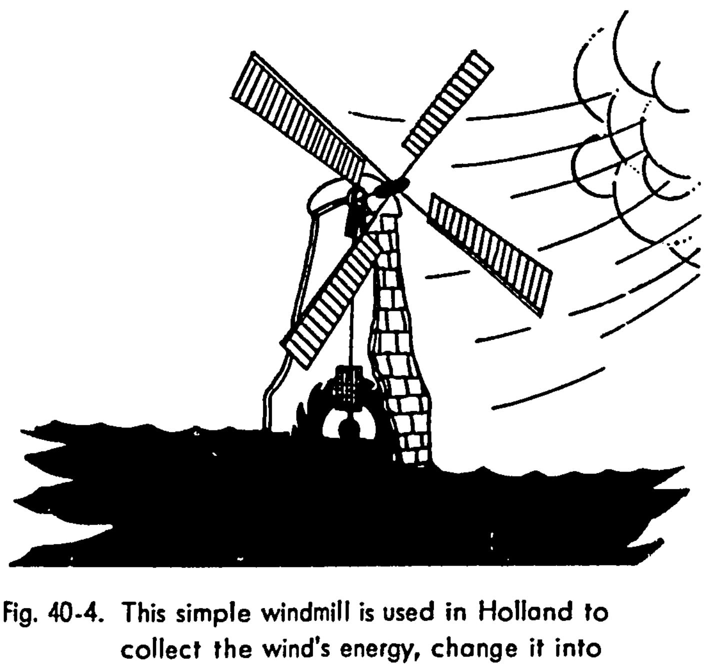


Fig. 40-4. This simple windmill is used in Holland to collect the wind's energy, change it into mechanical energy, and then to pump water from the lowlands.

Sailing ships and gliders are also examples of how man can put some of the wind's energy to work.

Greater use of the wind to get electrical energy is possible in the future. If we could harness all the energy of wind, it would be able to do twice as much work as waterpower does now.

Harnessing the Energy of Running Water

Another form of nature's energy was put to work early in man's history. It was the energy of running or falling water. The radiant energy of the sun *evaporates* (turns into clouds) a huge amount of water each day. The water returns to the earth as rain and snow. Part of it collects on land surfaces and runs into streams. In flowing to the sea, this water is able to do a great amount of work.

The earliest way of harnessing this energy was the waterwheel, Fig. 40-5. The waterwheel changed the energy of moving water into mechanical energy for running grain mills and sawmills.

Today, waterpower is used mainly to turn the *turbines* that *generate* (produce) electrical energy, Fig. 40-6. High water pressures are needed to turn the turbines. So waterfalls or water stored behind man-made dams are used. The high-pressure water is squirted through nozzles onto the turbine blades. The mechanical energy of the moving turbine blades turns a generator. The generator then produces electrical power. Then the electrical power is sent through high-voltage power lines to homes and industries. There it may be used to run machines and appliances, or it may be changed to heat and light.

Harnessing the Energy of Natural Fuels

The natural fuels include coal, oil, gas, and wood. They were all living things once. They all contain carbon. Plants change the radiant energy of the sun to chemical energy through the process of *photosynthesis*. Coal comes from plants, Fig. 40-7. Oil and gas come from small animals. When

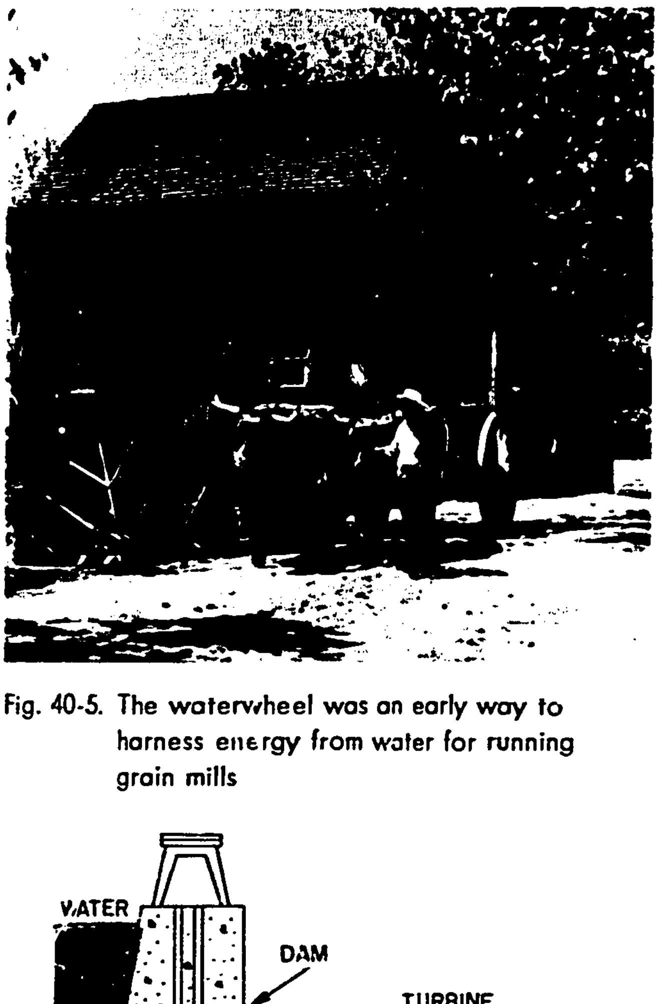


Fig. 40-5. The waterwheel was an early way to harness energy from water for running grain mills

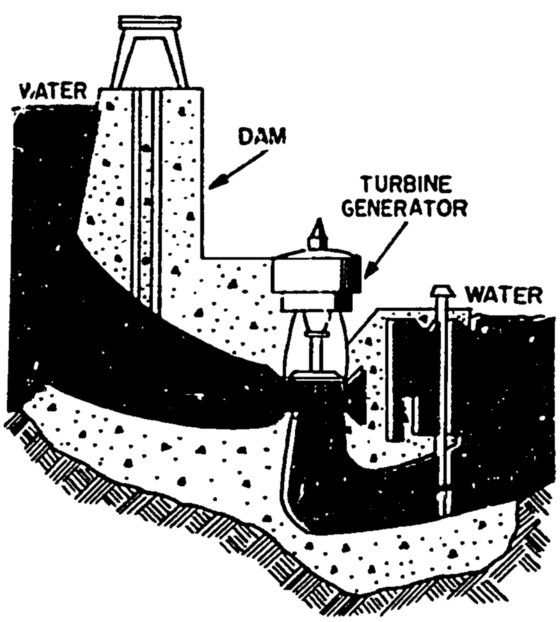


Fig. 40-6. Water is harnessed today by collecting it behind dams and forcing it through turbine generators.

these plants and animals were buried millions of years ago, their energy was also buried and stored. Harnessing this energy can be done in several ways. They are: (1) drilling for oil and gas, mining coal, and cutting wood; (2) refining (oil) into usable fuels; (3) moving and storing the fuel; and (4) controlling the burning of the fuel.

Controlled burning turns the stored chemical energy into heat energy. Then the heat energy can be used to heat homes and factories or to run automobile engines. It can also be used in manufacturing processes that need heat. Today, the natural fuels are our most important source of energy, but the supply is slowly growing smaller. In the future we must find either new fuel supplies or other sources of energy.

Harnessing the Energy of Nuclear Fission

Nuclear fission is often called "splitting the atom." The amount of energy let loose during this process is huge. When not controlled, the process results in terrible explosions. But if fission is controlled in a *nuclear reactor*, its energy is easily harnessed. The nuclear energy is changed into heat energy. This heat energy is usually used to heat water under pressure. The water is then changed to steam and used to turn the blades of a turbine. The moving turbine blades generate electrical energy. They can also *propel* (drive forward) nuclear-powered ships, Fig. 40-8.

The energy of nuclear explosions may one day be put to work to make new canals and harbors. It may even be used in some mining operations. Use of nuclear fission energy in industry is still developing. It will surely become one of man's most important sources of energy in the future, as our supply of natural fuels is used up.

Future Energy Sources for Man

In the future, man must learn to harness new sources of energy. But better use must be made of the energy sources he uses now. Our supply of natural fuels is rapidly being used up. It will probably last only a few hundred years.

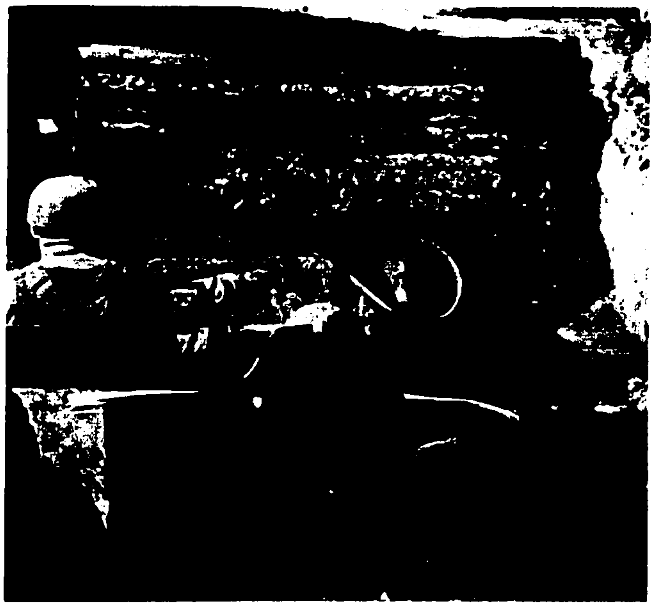


Fig. 40-7. Coal is one of our natural fuels. The coal must be mined first before its energy can be used by man.

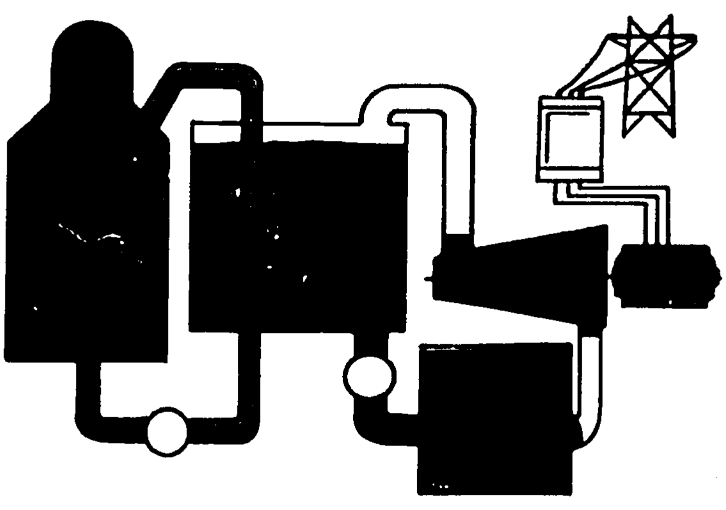


Fig. 40-8. Energy from a nuclear reactor can heat water under pressure. The water is changed into steam to run a turbine generator that produces electrical energy.

We are looking for ways to use new sources of nature's energy. Several of these sources are the power of the ocean's tides, the radiant energy of the sun, the natural heat under the earth's surface, the energy of the *laser* (light) *beam*, and *nuclear fusion* (combining atoms).

The energy used in the daily rise and fall of the oceans' tides could give man nearly half of his total energy needs. The world's first successful *tidal-powered* electric plant was built in France in 1966. The water of the ocean at high tide was blocked with dam arches across a bay, Fig. 40-9. As the tide fell, the water behind the arches was used to drive turbines for electrical power. Several such projects are being planned or built around the world.

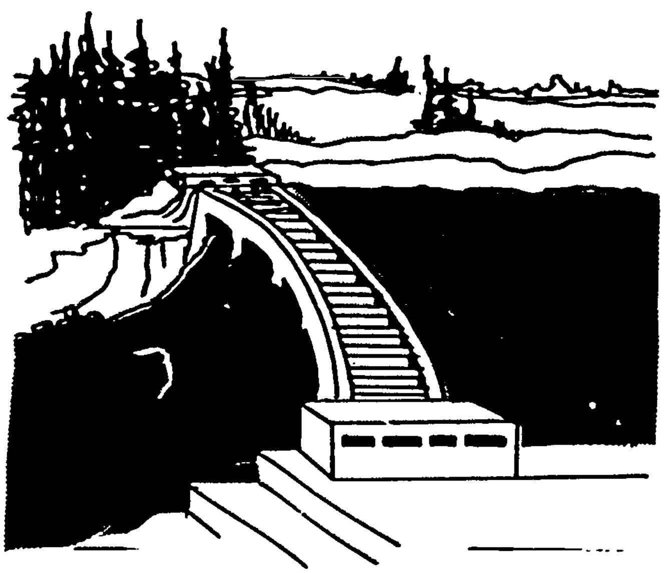
Today, man uses only a very small fraction of the total radiant energy from the sun. Every two days the earth gets an amount of energy in sunlight equal to all the earth's natural fuels left. To put sunlight to work, man must collect and concentrate the sun's rays with lenses and mirrors. This is very expensive.

Our problem is to develop cheap ways to harness this energy. *Solar energy* (sun) is now used to heat some specially designed homes, Fig. 40-10. In the future, *solar cells* will use radiant energy from the sun. These cells will change solar energy into electrical energy. Such cells are now used in *space satellites* to run instruments and radio transmitters.

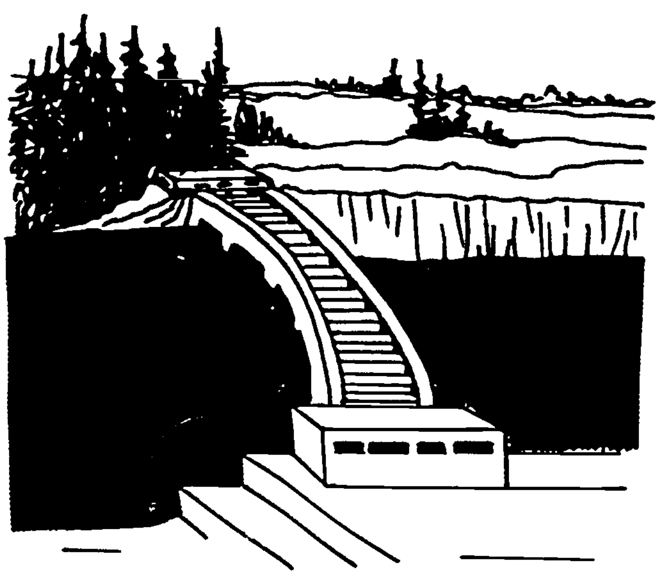
Under the earth's surface, *radioactive elements* decay and let loose large amounts of heat. Such high temperatures inside the earth can be seen at the surface in the heat of volcanoes and geysers. Steam produced by this underground heat may be used to drive turbine generators for electrical energy. The natural heat of the earth may also be used in the future to heat homes and factories.

The energy of the *laser beam* is being studied for possible use in the future. The intensified light beam of a laser may be used to carry energy which may be changed to electrical energy. We may not need high voltage transmission wires in the future. The laser beam may also be used as a communications transmitter and as a tool in surgery and delicate metal welding.

Probably the greatest source of energy harnessed by man is *nuclear fusion*. This is the process which gives energy to the



A. At high tide, the ocean water is dammed up in a bay.



B. At low tide, the water is used to generate electrical energy.

Fig. 40-9. Much of man's total energy needs can be supplied by the ocean's tides.

stars and the hydrogen bomb. Nuclear fusion is the opposite of nuclear fission. Nuclear fusion happens when two atomic *nuclei* (cores) combine to form one. The raw material used in this process is heavy hydrogen (*deuterium*). There is an almost endless supply of deuterium in the oceans. There are many complicated technological problems to harnessing this vast store of energy, but progress is being made, Fig. 40-11.

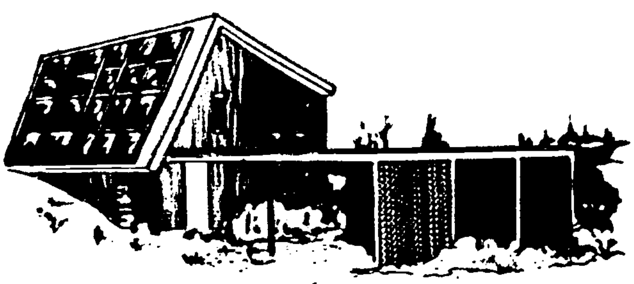


Fig. 40-10. Solar energy for heating homes can be collected with specially designed collector walls.

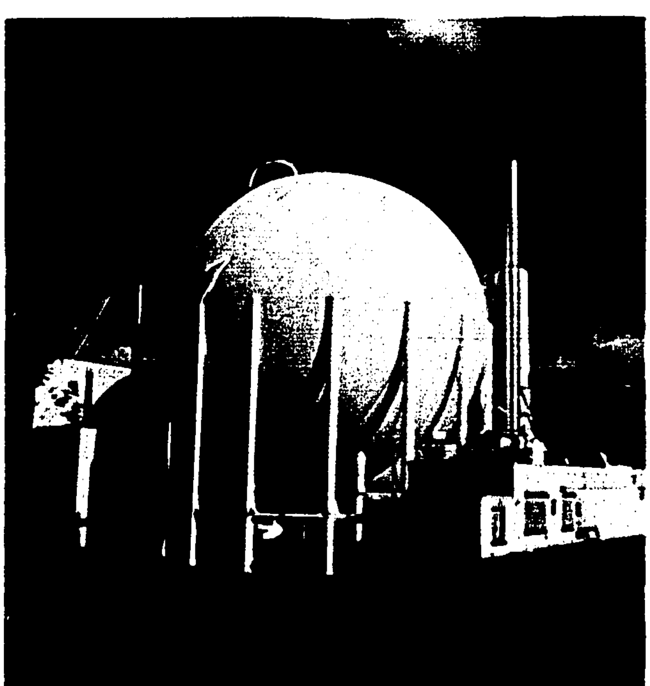


Fig. 40-11. Huge steel spheres enclose reactors at many leading nuclear power stations.

Summary

Everything man does needs energy. There are several natural sources of this energy. In order to do his work, man must harness them. There are six main kinds of energy. They are mechanical, radiant, chemical, heat, electrical, and nuclear. Each kind of energy may be changed into another kind. This is one of the jobs man faces in putting nature's energy to work for him.

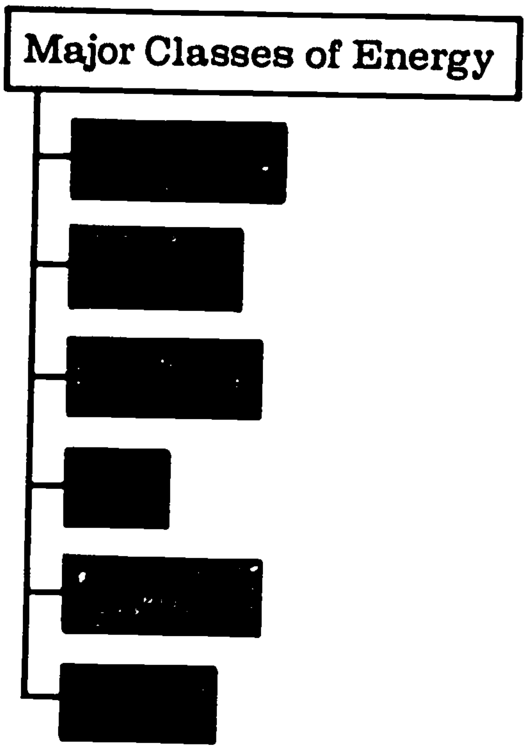
Man has learned to harness easily and cheaply the energy of the wind and moving water and the stored energy of natural fuels. He has been able to turn huge amounts of raw materials into useful products. His use of the energy found in nature has helped him a great deal.

Our supplies of coal, oil, and gas are being used up and these supplies cannot be replaced. We must, then, learn to harness some other forms of energy. We are now developing methods and equipment to harness the energy of the ocean's tides, the radiant energy of the sun, the natural heat energy of the earth, the light energy of the laser beam, and atomic energy.

Terms to Know

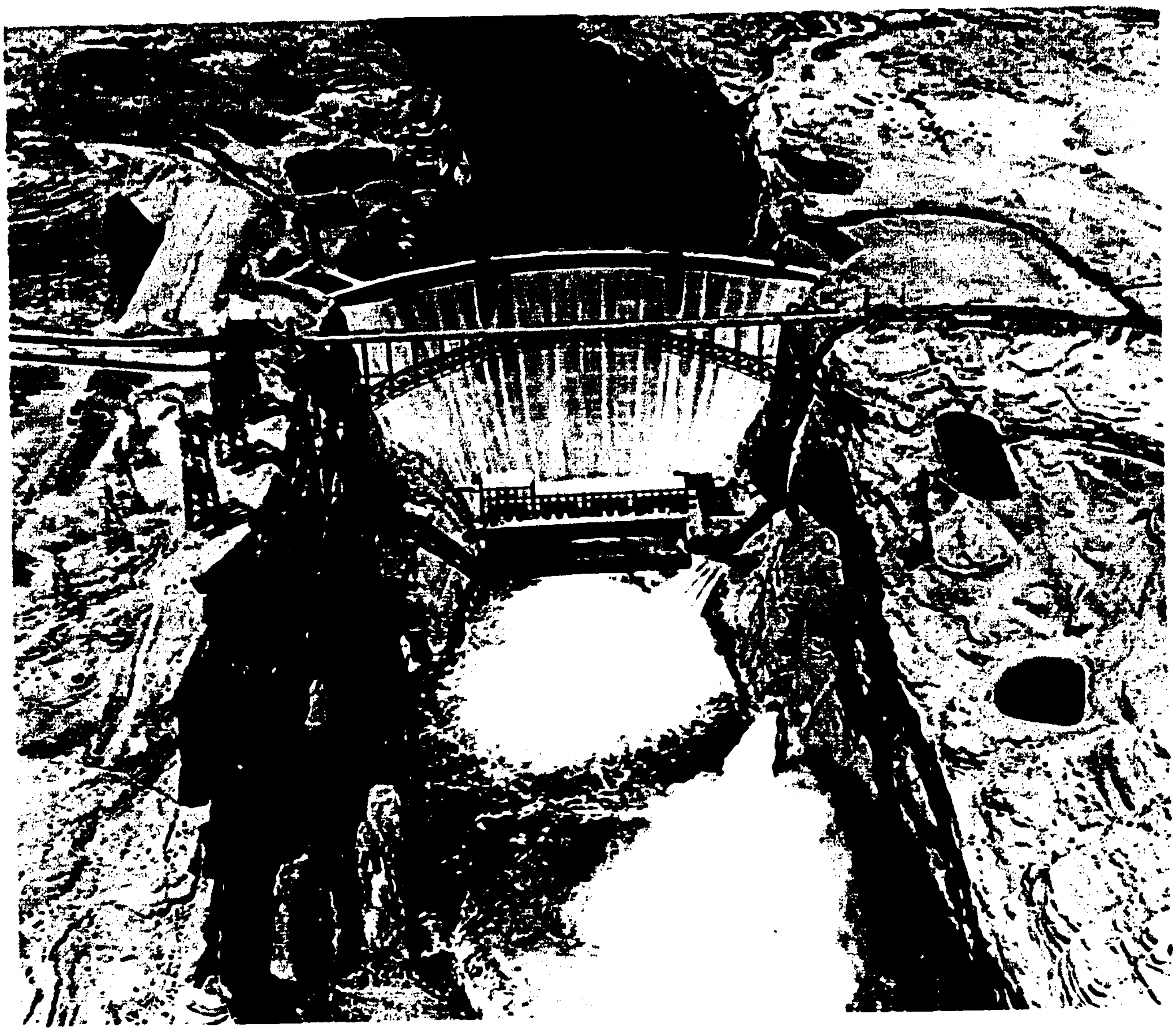
energy
- a. mechanical
- b. radiant
- c. chemical
- d. heat
- e. electrical
- f. nuclear

harnessed
nucleus
expends
fuels
collect
contain
control
topography
evaporates
turbines
generate
photosynthesis
nuclear fission
nuclear reactor
propel
laser beam
nuclear fusion
tidal-powered
solar energy
solar cells
space satellites
radioactive elements
nuclei
deuterium
(heavy hydrogen)
wind energy
pollution



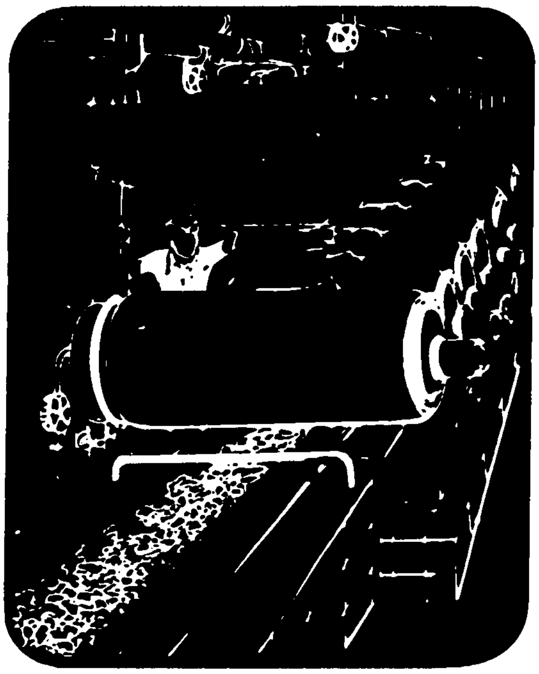
Think About It!

1. The use of natural energy means changing one form of energy into another. How can *wind* energy be used as a source of *electrical* energy?
2. Is it possible for the United States to generate too much electrical energy? What has this to do with air *pollution*?



Basic Manufacturing

Converting Raw Materials	Making Standard Stock	Making Components



Raw materials are collected and processed to remove the nonusable ingredients before they are converted into food, clothing, shelter, or other consumer products.

The above example shows the raw material (corn) after it has been harvested and delivered to a food company which will use it to make cereal, oil, starch, syrup, etc.

Standard stock (such as standard size and/grade wood, steel, glass, etc.) is made so the material can be processed by the available manufacturing equipment.

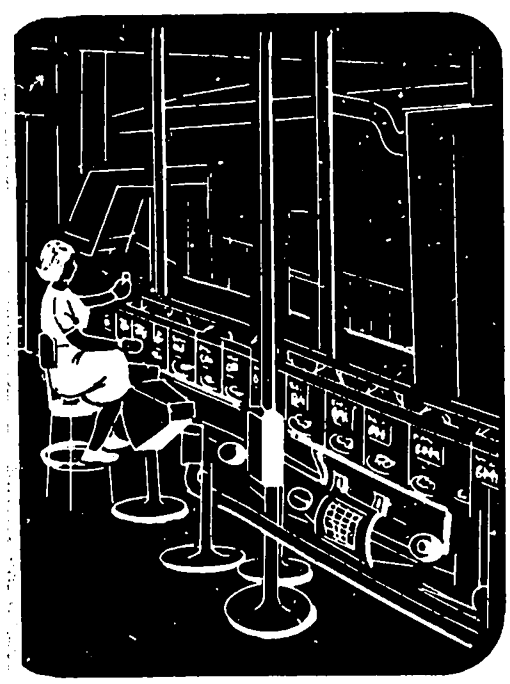
The above example shows the corn grain being treated and the flavoring added to become the standard ingredient for a breakfast cereal.

A finished product is made up of many manufactured parts.

The above example shows the corn flakes as a component of a product.

Production Concepts

Assembling



Components are assembled to become a finished product.

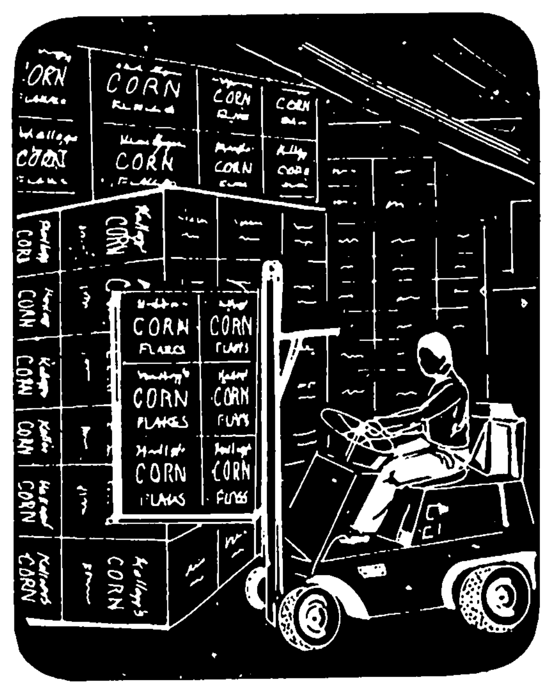
The corn flakes may be coated with sugar frosting to become a presweetened cereal. The flakes are weighed and assembled in an attractive package.

Finished Product

The finished product is carefully prepared to protect it and preserve it until it reaches the consumer.

The above cartons of corn flakes are sealed to maintain freshness and packed in a larger container for easier handling.

Preparing for Distribution



Finished products are usually stored in a warehouse until orders are received from the consumers. Finished products are loaded onto trucks, boats, planes, or railcars to be transported to the consumer.

The corn flakes are now being taken to a railcar with a fork lift truck.

Manufacturing Production Technology

You have learned that before production can start, products must be researched, designed, and engineered. Production processes and plant layout must also be decided on. Production and quality control systems must be planned. Personnel, equipment, materials, and other inputs must be gotten. *These are all basic management jobs.* Planning, organizing, and controlling are done in all these jobs. Management jobs will go on during the next step in manufacturing called *production.*

In this reading, you will learn how all kinds of manufacturers, using different materials, produce any kind of product. You will study the production steps all materials go through and the practices used to change the form of a material in each stage.

Production Stages

In the making of any product, there are steps to be followed in order. First, raw materials must be *refined* (improved) and *bulked* (combined in large quantities). This is called *preparing raw materials,* Fig. 41-1. Next, these materials are changed and formed into standard industrial materials. This is called *making industrial materials,* Fig. 41-2. Then, the standard materials are changed into *components* (single parts) or finished products made up of only one part, Fig. 41-3. Then, several components are *assembled* (combined to form a more complicated product), Fig. 41-4. Finally, the product is packaged or prepared for shipment, Fig. 41-5.

There are three important things to keep in mind about these steps. *First,* a material can become a product at any time. It becomes a *producer's product* if it is used by another manufacturer or a constructor. It is a *personal product* if it is bought and used by an individual, for example, in his home. *Second,* materials that are processed by *primary manufacturers* (primary metals, textiles, petroleum, chemicals, energy, lumber, and others) produce *by-products.* These become products for still other manufacturers. This cycle is nearly endless. *Third,* manufacturing production can be thought of as changing material from the general to the particular. This means from rough to fine; from general sizes, shapes, and weights to very accurate sizes, shapes, and weights; and from general skills to special skills. A chart at the end of this reading (Fig. 41-15) shows the production steps through which some materials are changed into products.

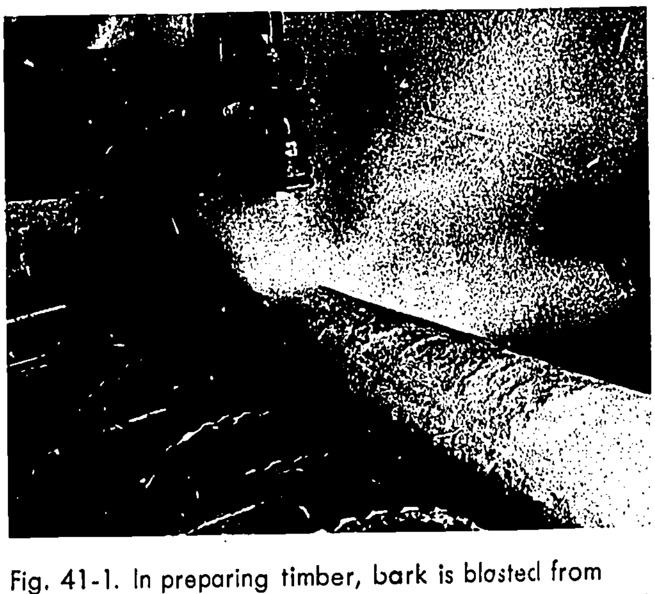


Fig. 41-1. In preparing timber, bark is blasted from logs by jets of water under 1,500 pounds of pressure. Slabs and endings are changed to chips for pulp and other wood paper products.

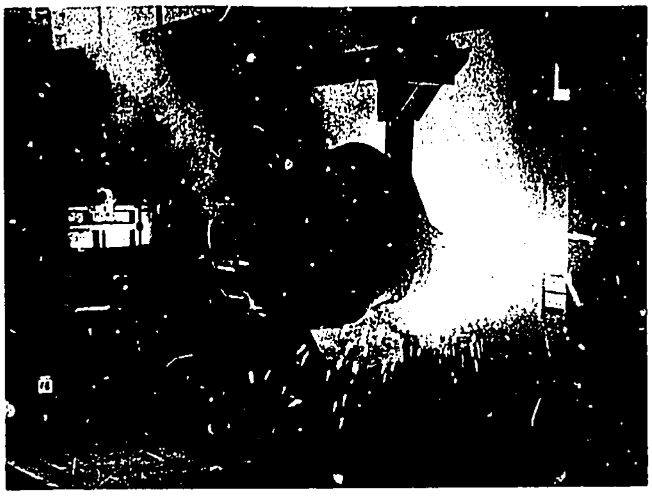


Fig. 41-2. Here you see molten (melted) iron in a basic oxygen furnace to be made into a high-quality steel. The steel will be formed into industrial materials.

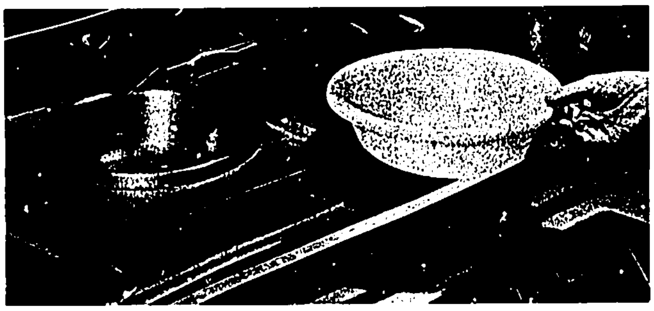


Fig. 41-3. In component making, a plastic sheet is vacuum-formed over an aluminum die to produce a dishpan.

Fig. 41-4. A diesel-electric locomotive is carefully lowered onto its trucks during a final assembly operation.

Production Practices

There are three main kinds of production practices. They are:

1. Preprocessing,
2. Processing, and
3. Postprocessing.

Preprocessing may be thought of as the ways we get the necessary inputs where they are needed and when they are needed. *Processing* may be thought of as the ways we change the basic form of the materials. *Postprocessing* may be thought of as the ways we service or maintain the products during their lifetime.

Preprocessing Materials

Preprocessing gets materials where they are needed, when they are needed, and in the right amounts. There are many ways to handle materials well. Handling materials well depends on the kind of material, the kind of equipment used, and how well the

Fig. 41-5. Delicate electrical and electronic control equipment is wrapped with polyethylene sheeting. During shipping, transport personnel can see what they are handling. The film also seals the equipment, protecting it from surrounding conditions.

material handling system has been combined with processing. Good handling may include carrying materials by hand, using automatic equipment, and moving materials through *conduits* (pipes or channels), Fig. 41-6. Whatever means is used to handle materials, it is done by one or a combination of several practices. These include:

1. *Receiving,*
2. *Unpacking,*
3. *Handling,*
4. *Storing,* and
5. *Protecting.*

Keep in mind that none of these practices changes the form of the materials.

Processing Materials

Materials are changed in form in three basic ways. Materials can be:

1. *Formed,*
2. *Separated* (Fig. 41-7), and
3. *Combined* during processing (Fig. 41-8).

Forming, separating, and *combining* are the main practices of processing. They take place during all stages of production. Material handling, storing, and protecting may also take place before, during, and after any of the five steps of production, Figs. 41-9, 41-10, and 41-11.

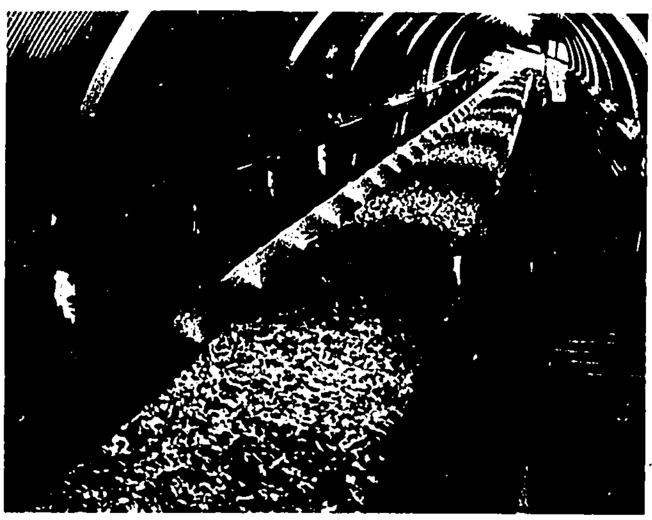


Fig. 41-6. Conveyor belt systems move many kinds of loose materials to stages of manufacturing.

With a deck of cards, you can bend the deck (forming), cut the deck (separating), and shuffle the deck (combining). These three practices apply to any material whether it is a solid, liquid, or gas. When you pick up the cards to bend, cut, or shuffle them or when you pass the deck to another person, this could be called *material handling.*

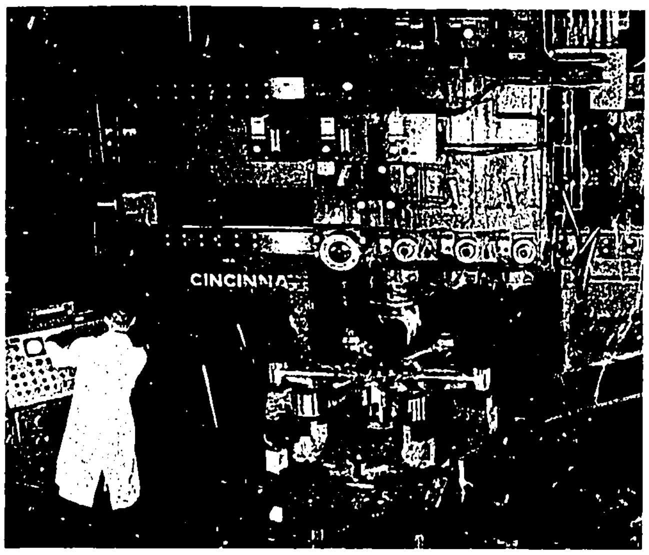


Fig. 41-7. The use of tape-controlled devices like this three-spindled bridge milling machine helps to form finely detailed helicopter parts. This machine reduces manufacturing work.

Fig. 41-8. Some materials are combined by mixing, as in blending pulps to make papers. Dyestuffs, sizing, and fillers are also mixed to produce the right color in the finished product.

Let us take other examples. If you are bending wire, you are forming. If you are sawing wood, you are separating. If you are stapling two sheets of paper together, you are combining.

In manufacturing there are many special practices used to form, separate, and combine standard stock, Fig. 41-12.

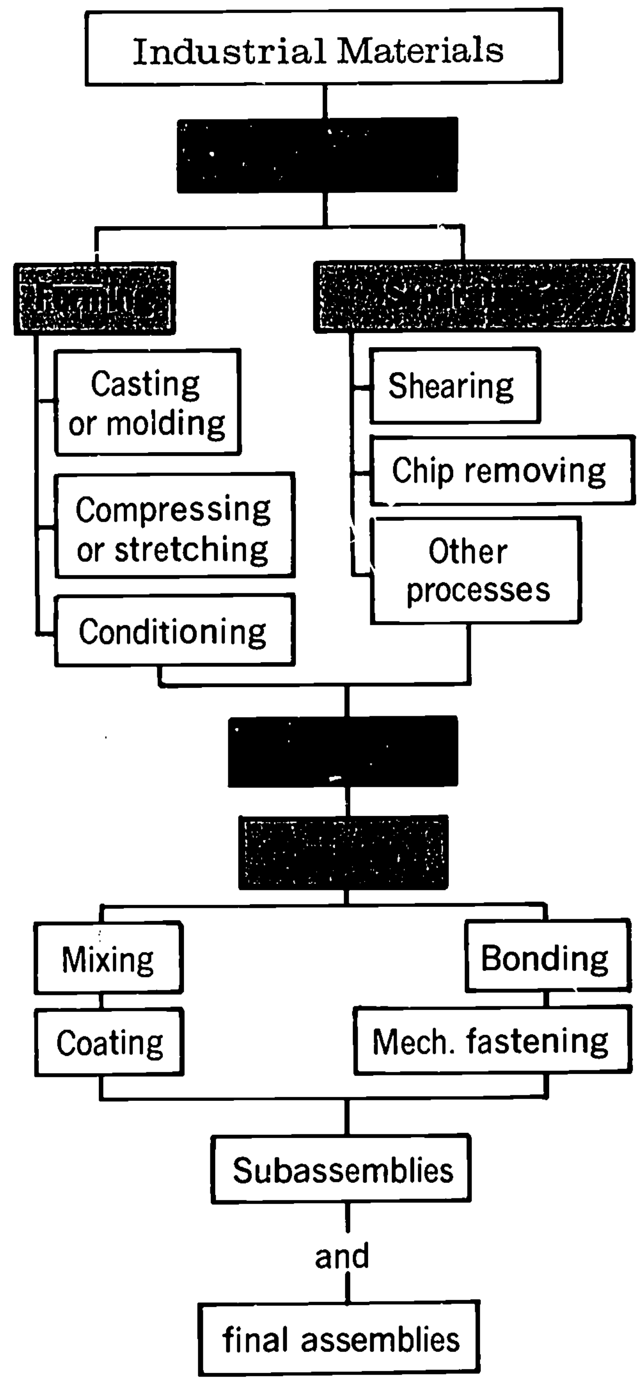


Fig. 41-9. Main practices of processing.

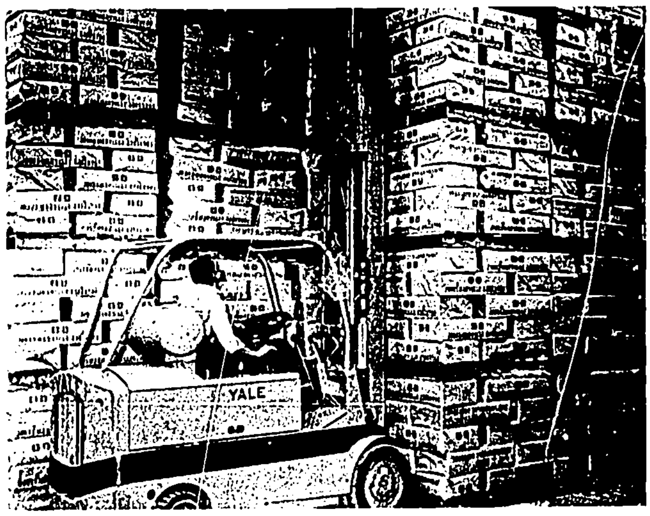


Fig. 41-10. Many materials are stored and handled by a fork-lift truck before processing.

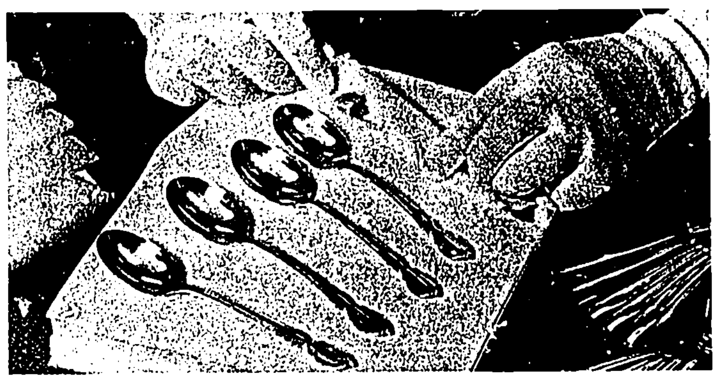


Fig. 41-11. After processing, each piece of flatware is carefully wrapped in sulphur-free tissue paper before it is finally wrapped in tarnish-resistant paper to protect it on its way to the customer.

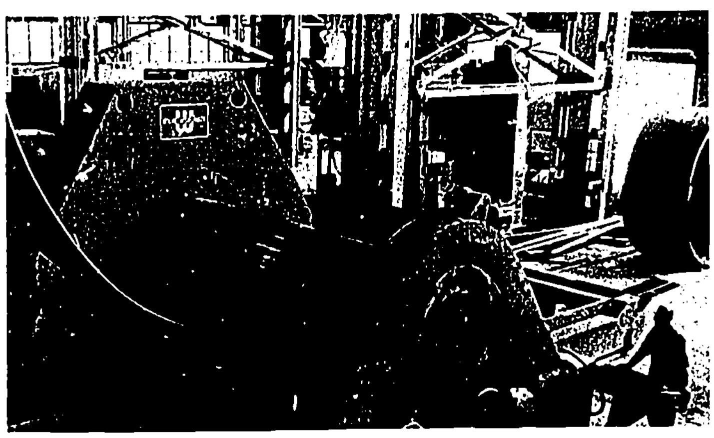


Fig. 41-12. Here a workman is forming a large wheel for an earth compactor by passing the sheet through rollers.

Look at some products around you, and see if you can tell which practices have been used to change the forms of materials in each step of production. By doing this, your understanding of the manufactured world will increase.

Postprocessing Materials

Postprocessing materials includes:
1. *Installing*,
2. *Maintaining*,
3. *Repairing*, and
4. *Altering*.

These happen after the product gets to the customer. They are practices that increase the life and value of manufactured goods. Often they are called *servicing*, Fig. 41-13.

Many manufactured products are *installed* (put in place) in buildings by building contractors. This service, however, may be done by the manufacturer if the contract states that he will do it. An example is the installation of an air conditioning system or a public address system in your school.

Fig. 41-13. A rear-projection comparison viewer is being installed by the manufacturer of the viewer.

If your family automobile is not running right, a tune-up is done at a garage, service station, or at home. This is an example of *maintaining* the product (keeping it in good shape). When you polish your shoes, you are maintaining them.

The practice of repairing is a common activity. New soles or heels can be put on your shoes to make them like new. If you should break the windshield of your family automobile, it could be *repaired* by putting in a new windshield.

Examples of *altering* are cutting down a pair of trousers that belonged to your older brother, or cutting a carpet to fit a room. Some day, you may mill down the head of your automobile's engine to increase its power.

These are only examples of the many postprocessing practices that are done to manufactured products. It is important to remember that the knowledge used in postprocessing is the same basic knowledge used in processing. It is just done at a later time and at a different place.

Production Technology

All technology is aimed at learning how to do something *efficiently*. To do something efficiently means that man must be able to plan, organize, and control what he is doing. The way men have efficiently planned, organized, and controlled their management, personnel, and production practices gives us a managed-production system. The knowledge of efficient practices in manufacturing production is called *manufacturing production technology*.

You should be able to understand the relationships among the technologies of manufacturing by studying Figs. 41-14 and 41-15.

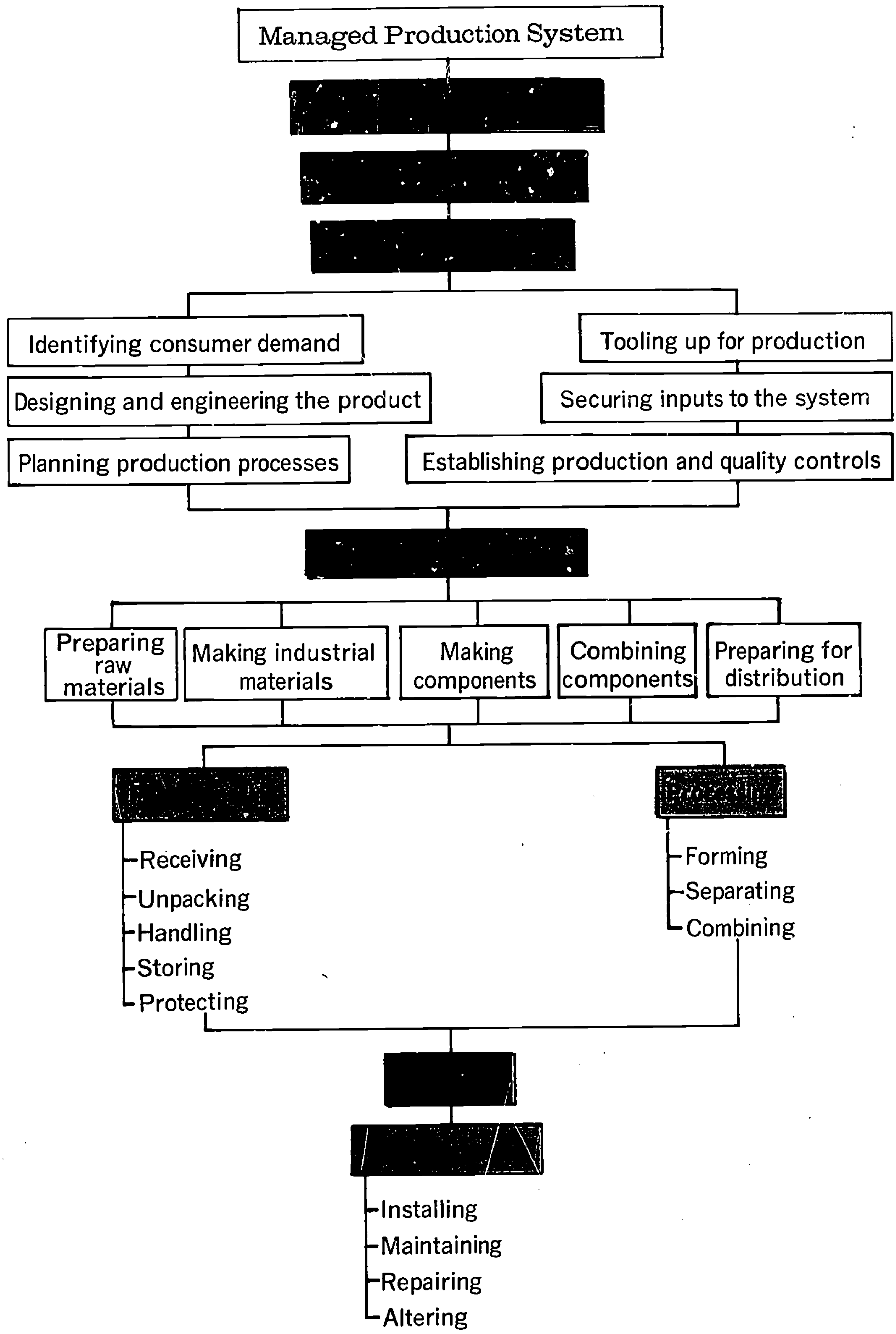


Fig. 41-14. Relationships among Manufacturing Technologies

STAGES OF PRODUCTION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Timber
Preparing Raw Materials	logs debarked	separated from impurities, cast into pig iron ingots	combed, washed	separated from impurities, coagulated, dried	washed, filtered	filtered	filtered, solids separated from liquids	logs debarked
Making Industrial Materials	rough sawed, kiln and air dried lumber	refined ore — made into steel sheets, bars	spun into yarn — woven into fabric, bleached	refined, dewatered into sheets, pellets, bails	distilled into raw gasoline, tar, kerosene, etc.	pasteurized	settled	ground, bleached, slurried, screened into pulp sheets
Making Components	shaped to dimensions: thickness, width, e.g., ⅜″ x 36″ dowel	sheet steel printed and stamped into bottle caps	dyed, cut into sleeves, collars, cuffs, bodies of shirts	sheets compounded, laminated and formed into belts	raw gasoline cracked into grades of gasoline	butterfat and whey extracted	leached, aerated	reground, slurried, screened into logs of paper
Combining Components	combining of parts: points, feathers, paint, dowels	cork inserted into cap	fabric parts sewed together — buttons, labels added	fabrics and rubber belts vulcanized into tires	lead, color, lubricants, octanes added	water, vitamins, preservatives added	chemicals batched in correct amounts to purify	logs printed, cut, folded into newspapers
Preparing for Distribution	packaged in lengths, types, quantities	packaged in quantities, brands	packaged by quality, color, style, size	wrapped and gathered into lots	collected into storage tanks or distributed by pipelines	bottled in containers by weight, grade, type	piped into reservoir or storage tanks or into streams	bundled by quantity
Sample Products	Brand A 34″-6 oz. target arrow 1 gross	Brand B soft drink bottle caps 1 gross	Brand C 16-32 white French cuff dress shirt 1 doz.	Brand D 6:50-15, 4-ply snow tire 500	Brand E Blue ethyl 110 octane automotive gasoline 1000 gal.	Brand F white, vitamin enriched, whole milk 100 qt.	Brand G reclaimed fresh water	Brand H morning newspaper, 24 pages, 50 per bundle

Fig. 41-15. Basic Production Stages

Summary

Manufacturing production technology is the knowledge used by man to change raw materials into manufactured products. It also takes personnel and management knowledge and skill to add value to materials by changing their form. There are five steps in production. They are:

1. Preparing raw materials,
2. Making industrial materials,
3. Making components,
4. Combining components, and
5. Preparing for distribution.

In each step many kinds of preprocessing and processing take place. The forms of materials are changed in each step. Installing, maintaining, repairing, and altering of manufactured products are postprocessing practices. They are usually called *servicing*.

Terms to Know

production
refined
bulked
preparing raw materials
making industrial materials
components
assembled
producer's product
personal product
primary manufacturers
by-products
preprocessing
- a. receiving
- b. unpacking
- c. handling
- d. storing
- e. protecting

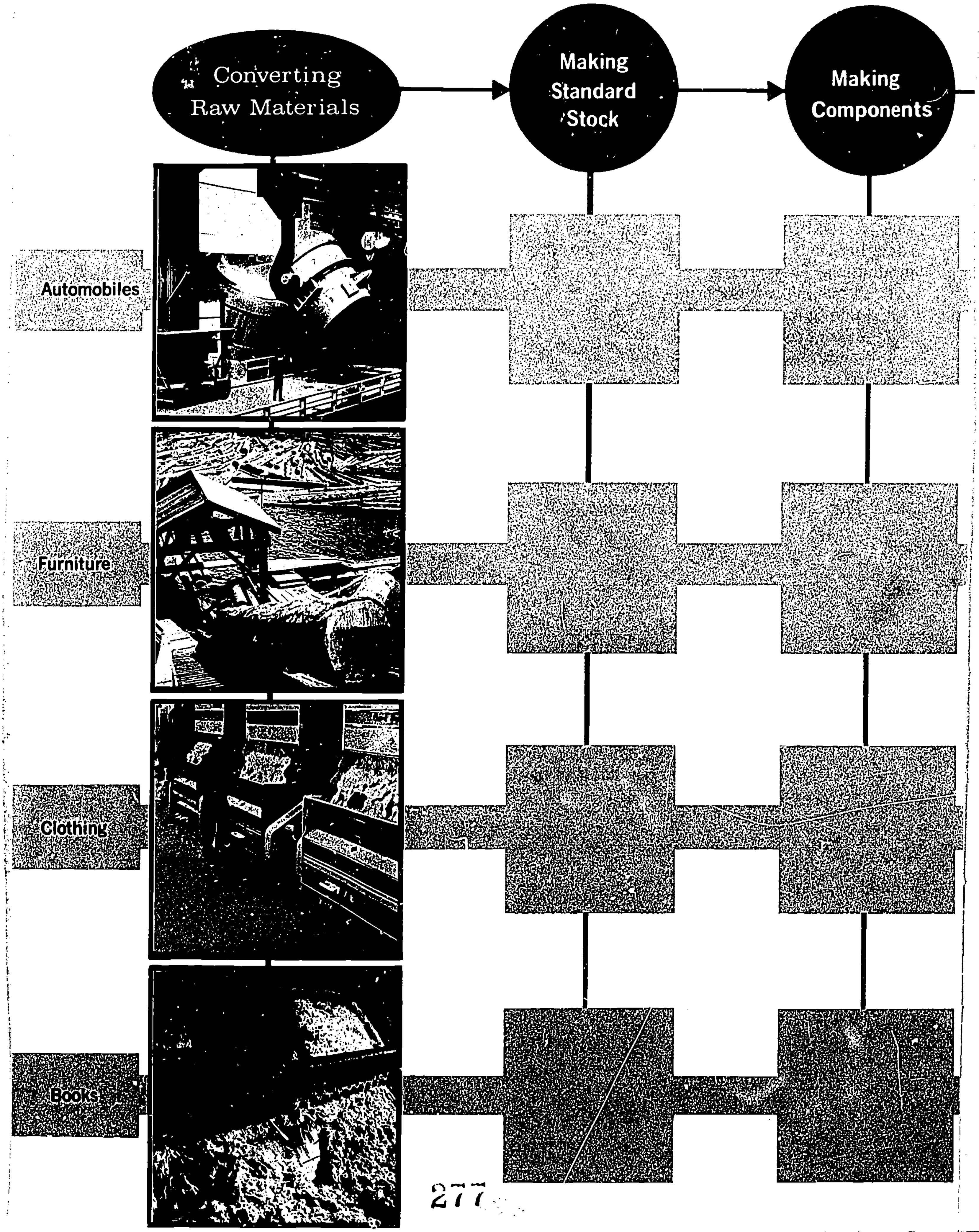
processing
- a. forming
- b. separating
- c. combining

material handling
postprocessing (servicing)
- a. installing
- b. maintaining
- c. repairing
- d. altering

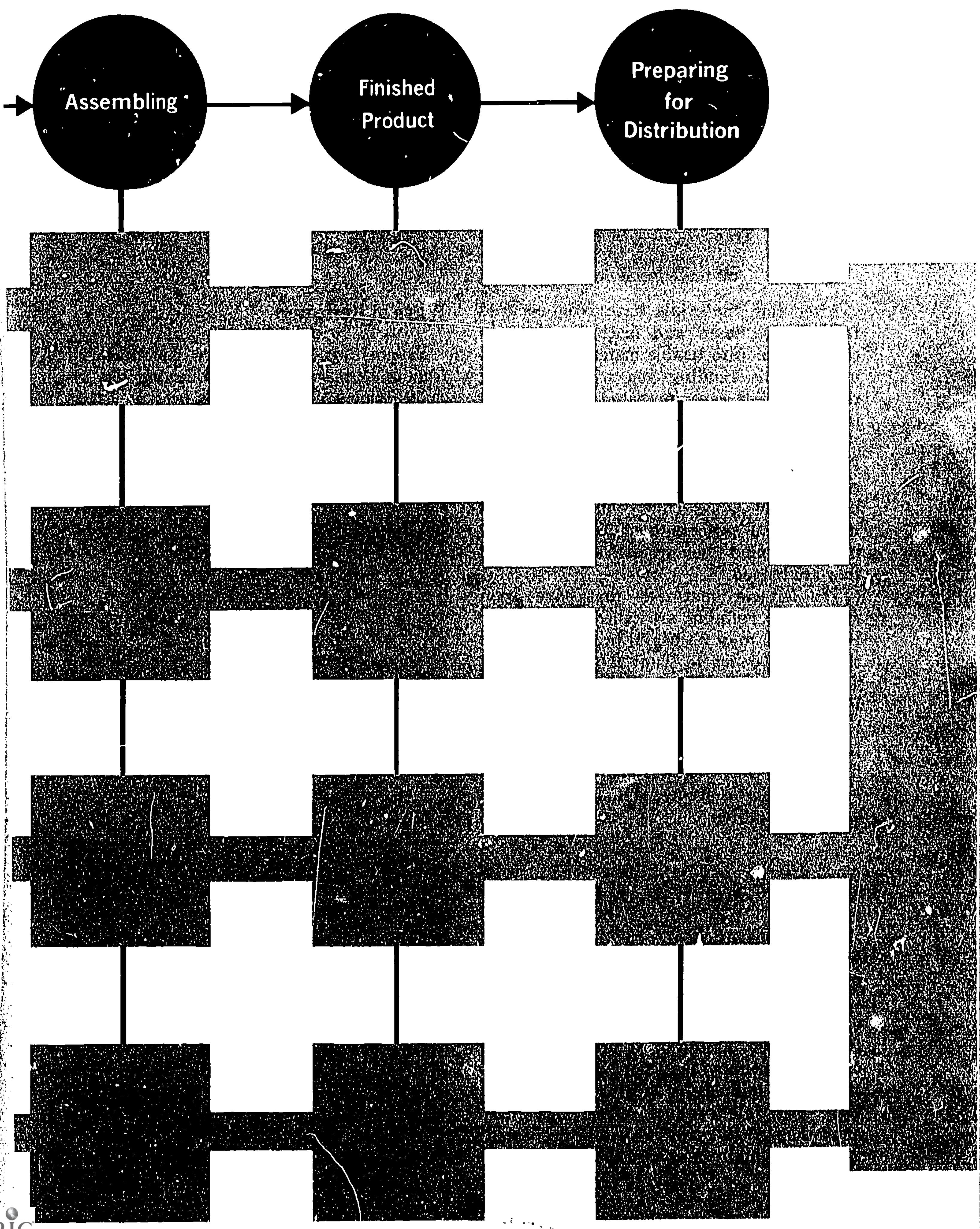
efficiently
manufacturing production technology
conduits

Think About It!

1. How do production practices add value to raw materials?
2. If technology tries to find how to do something *efficiently*, in what ways do you see the results of technology in your home?



Converting Raw Materials
Making Standard Stock
Making Components
Automobiles
Furniture
Clothing
Books


Assembling
Finished Product
Preparing for Distribution

READING 42

Converting Raw Materials to Industrial Materials

After raw materials have been secured from nature, men and machines start to change them into usable materials or products. In this reading you will learn how raw materials are prepared for use by industry.

Most raw materials must be separated from unwanted materials. This activity is called *refining*. The wanted materials may be stored in large (*bulk*) quantities until it is time to process them further. Other materials must be processed as soon as they are refined.

The leftover materials that have been removed by refining are called *by-products*. By-products may be useful in some way, or they may be *waste* (unwanted) material. Today we have very few waste materials. For example, the bark is removed from logs that are to be used for fence posts or paper, Fig. 42-1. A by-product of this refining is the bark that is stripped from the log. Bark can be processed and sold in sacks as a garden mulch.

Where Raw Materials Are Prepared

Some preparation of a raw material takes place when it is taken from nature. Sugar beets, for example, are shaken free of dirt in the field before they are piled up, Fig. 42-2. Most coal is sorted and washed at the coal mine. Crude oil is prepared in the oil field by removing water, gas, and sand. It is then bulked in large storage tanks. Some materials are not refined until they enter the plant where they will be processed. Still other materials need no preparation at all.

Ways of Refining

Refining processes remove one material from other materials. The following list includes some kinds of refining processes that are widely used. There are many others.

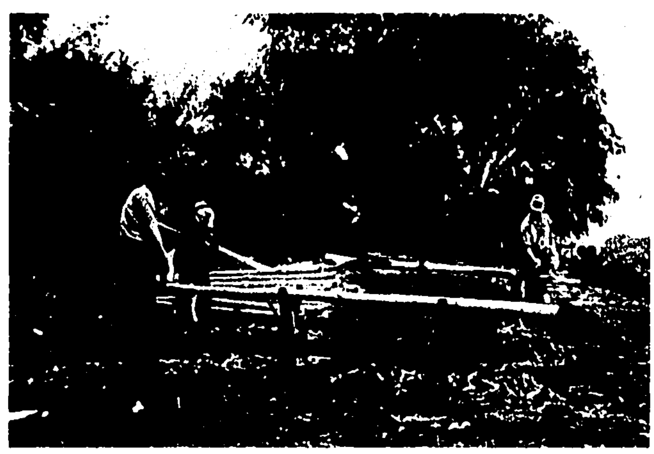


Fig. 42-1. The bark is stripped from these logs which are to become posts. The bark is a by-product.

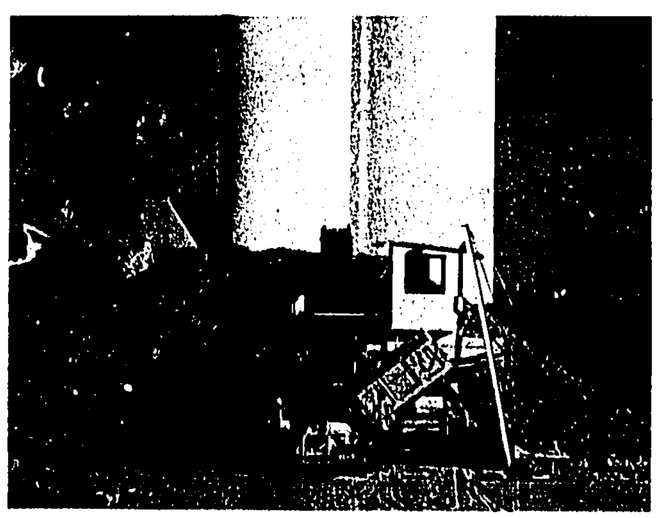


Fig. 42-2. These sugar beets were shaken free of dirt in the field before they were piled up.

1. *Washing* and *cleaning* are ways to remove unwanted materials like sand, gravel, dirt, and bacteria from ore, meat, vegetables, and fruit.
2. *Screening* and *sizing* remove unwanted material. They also separate the raw materials by size. Coal, gravel, eggs, and potatoes go through screening and sizing processes.
3. *Sorting* and *classifying* are ways of getting the same quality in one batch of material.
4. *Settling* removes sand and dirt from petroleum, water, or other liquid materials.
5. *Flotation (floating)* is used with ores, oils, and fats.
6. *Cutting* removes corn from the cob and oysters from their shells.
7. *Filtering* removes solids from liquids such as water and milk.
8. *Peeling, stripping, husking, shelling, scaling,* and *skinning* remove coverings from fish, meat carcasses, fruits, vegetables, and other reproducible raw materials.

Controlling Raw Materials Quality

Earlier you learned about quality control systems. Quality standards are also applied to raw materials. A material that does not meet the standards for manufacturing one industrial material or product may meet the standards for another product, material, or by-product. *Standards* are set to meet customer needs, health factors, and safety *policies* (rules). Some standards are set by law. Examples of materials standards are:

1. The moisture content of wheat cannot be more than 5 percent of the total weight.
2. The butterfat content of milk should not be less than 3.5 percent.

Bulking

Bulking consists of *measuring, weighing, collecting,* and *unitizing*. A material may be measured by the inch, foot, mile, cubic yard, or bushel. A material may be weighed by the ounce, pound, or ton. Collecting means piling up the material, Fig. 42-3. Unitizing means placing material in the same amounts or in units of the same size, shape, volume, or weight. The unit may be a case, drum, bushel, carload (railroad), ton, or bale, Fig. 42-4.

Fig. 42-3. Some raw materials are prepared and stored in large open areas. These materials have been collected in piles.

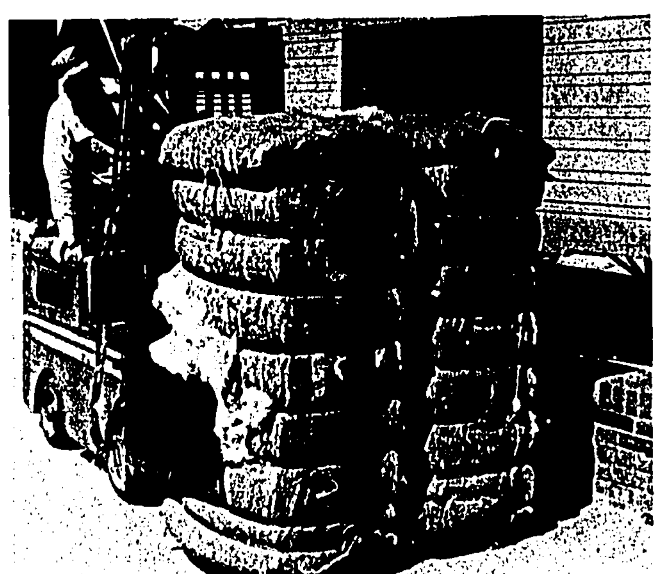


Fig. 42-4. Cotton is "bulked" into bales. This 500-pound bale is on its way to a textile plant.

Storage, *handling*, and *transportation* (moving from one place to another) must be planned so that bulking operations can be done cheaply and well. The best *transport systems* (hauling vehicles) must be selected to move materials long distances. Lift trucks, conveyors, or cranes may be needed to move materials short distances.

Converting

Converting means changing a raw material into an industrial material. The change may be physical, chemical, or both. Primary metal manufacturers convert metal *ores* into metals. For example:

1. Iron ore is converted into pig iron in a blast furnace.
2. Pig iron is converted into steel by adding scrap steel and other metals, Fig. 42-5.
3. Bauxite is converted into aluminum.
4. Copper ores are converted into copper.

Logs cut down for paper are converted into chips. Next, the chips are converted into *pulp*. The pulp is then bleached or dyed to make p iper stock.

Petroleum is converted by distilling into eight basic industrial materials:

1. Fuel gas,
2. Straight-run gasoline,
3. Naphtha,
4. Kerosene,
5. Gas oil,
6. Residue,
7. Asphaltic residue, and
8. Lubricating residue.

Figure 42-6 shows a plant where petroleum is converted.

The textile industry converts *fiber* (a raw material) into thread or yarn (an industrial material). Later the yarn will be made into cloth, a standard stock in a textile mill.

The glassmaking industry converts silica sand and other refined raw materials into *molten* (melted) glass. This molten glass can be made directly into a glass bowl, or it can be made into a common standard stock item called *sheetglass*, Fig. 42-7.

Most people never see these materials until they have been further processed. Converting, as you can see, changes the raw material into a usable industrial material.

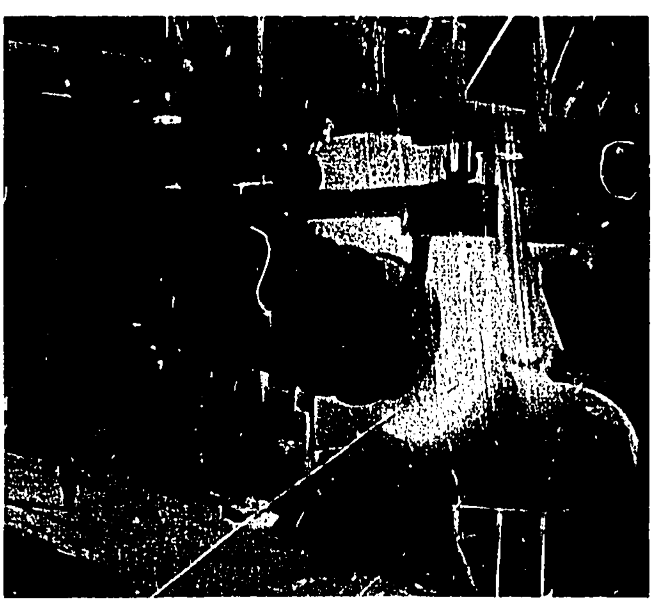


Fig. 42-5. Pig iron is poured into a Bessemer converter. It will be combined with scrap metal to make steel.

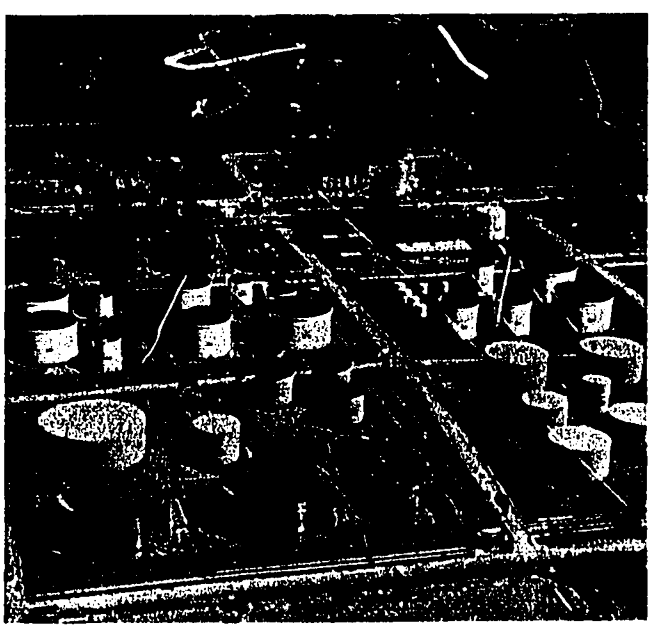


Fig. 42-6. This is an aerial view of a plant for converting petroleum into its eight basic industrial materials.

Where Converting Is Done

The place where a raw material will be converted depends on the raw material itself. For example, wool is not converted to yarn on a farm. But, on some large farms, milk is converted into *pasteurized* milk. People who work in converting operations, then, may work near the source of the raw materials, or they may work several hundred miles from where the material was secured.

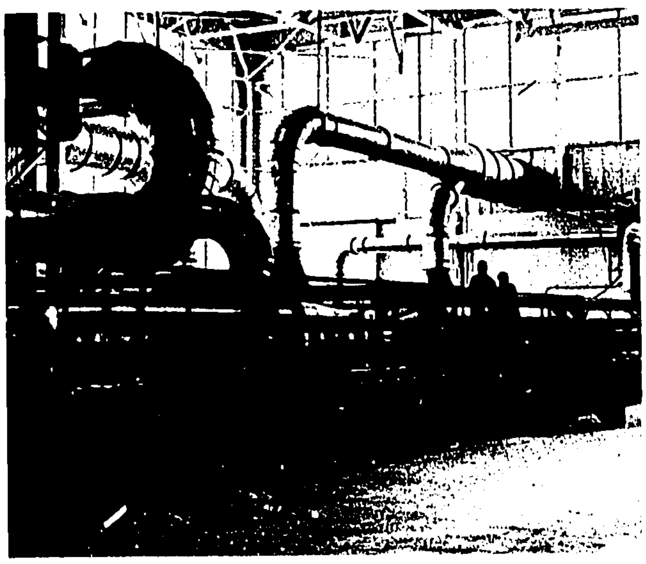


Fig. 42-7. Glass flows from a furnace in a continuous sheet. Next it will be cut into standard stock.

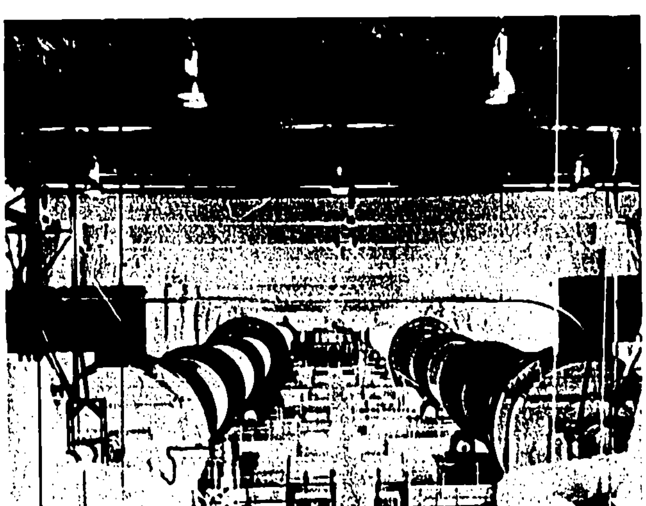


Fig. 42-8. Cement is roasted in long, rotary kilns. The raw materials are heated to 2600°–3000°F.

Ways of Converting

There are many different kinds of processes for converting raw materials into industrial materials:

1. *Butchering* is the converting of animal carcasses into sides or quarters of meat which are later made into steaks, chops, or sliced meats.
2. *Distilling* separates a liquid from some other material by making it *evaporate* and then *condense* again. It is used by petroleum producers. It is also used to get fresh water from seawater. In these fields, *refining* and *converting* mean almost the same thing.
3. *Melting* is a basic converting process for producing primary metals and plastic resins.
4. *Evaporating* is used to convert such materials like sugar and salt to more usable forms.
5. *Filtering* converts gas, sugar, and many liquids to more usable forms.
6. *Roasting* produces chocolate, cement, and many other industrial materials. Figure 42-8 shows a kiln in which cement is roasted.

Summary

Most raw materials must be separated from other materials that are mixed with them in nature. This kind of activity is called *refining*. The materials left over after refining (*by-products*) may also be useful. Sometimes they are unwanted (*waste*) materials.

After a raw material has been refined, it is collected and may be stored in large *bulk* quantities until it can be processed further.

Many refined and bulked raw materials are converted into industrial materials. Con-

verting produces a physical or chemical change (or both) in a material. Figure 42-9 shows three converting processes used in papermaking. The average consumer usually does not see industrial materials. The manufacturer continues processing them to produce standard stock.

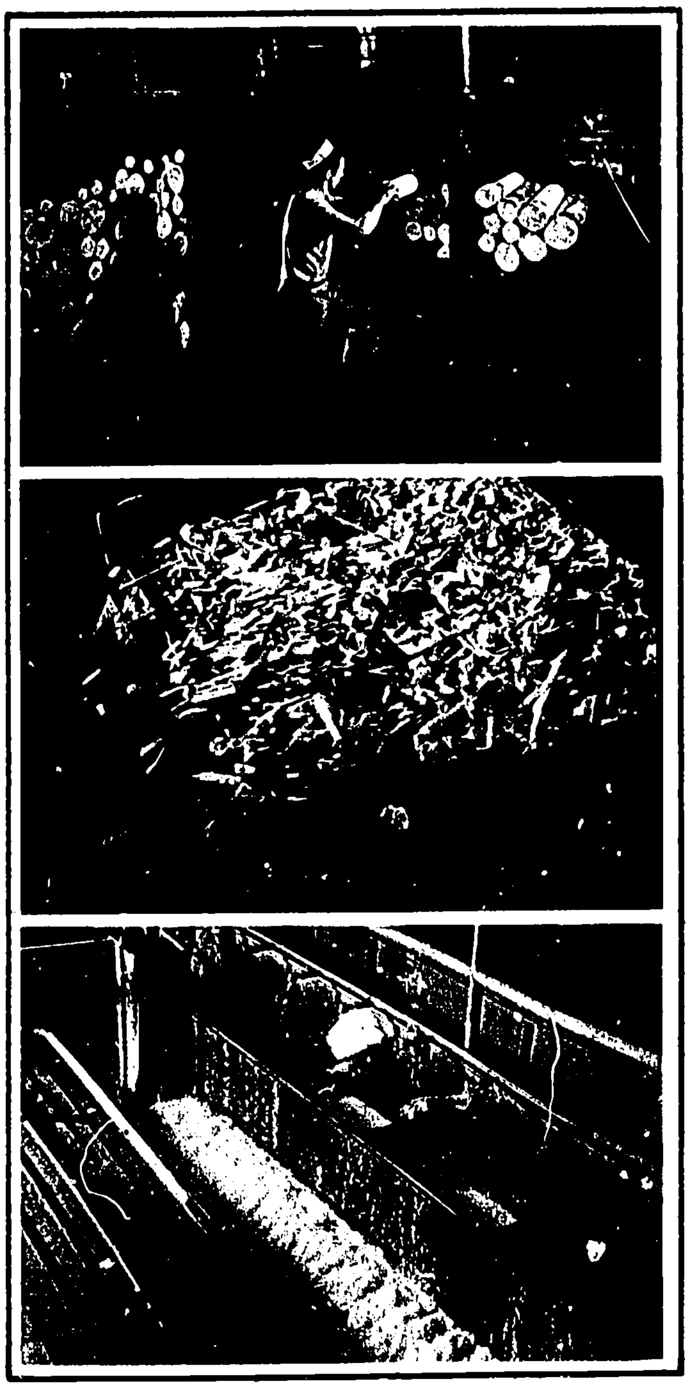


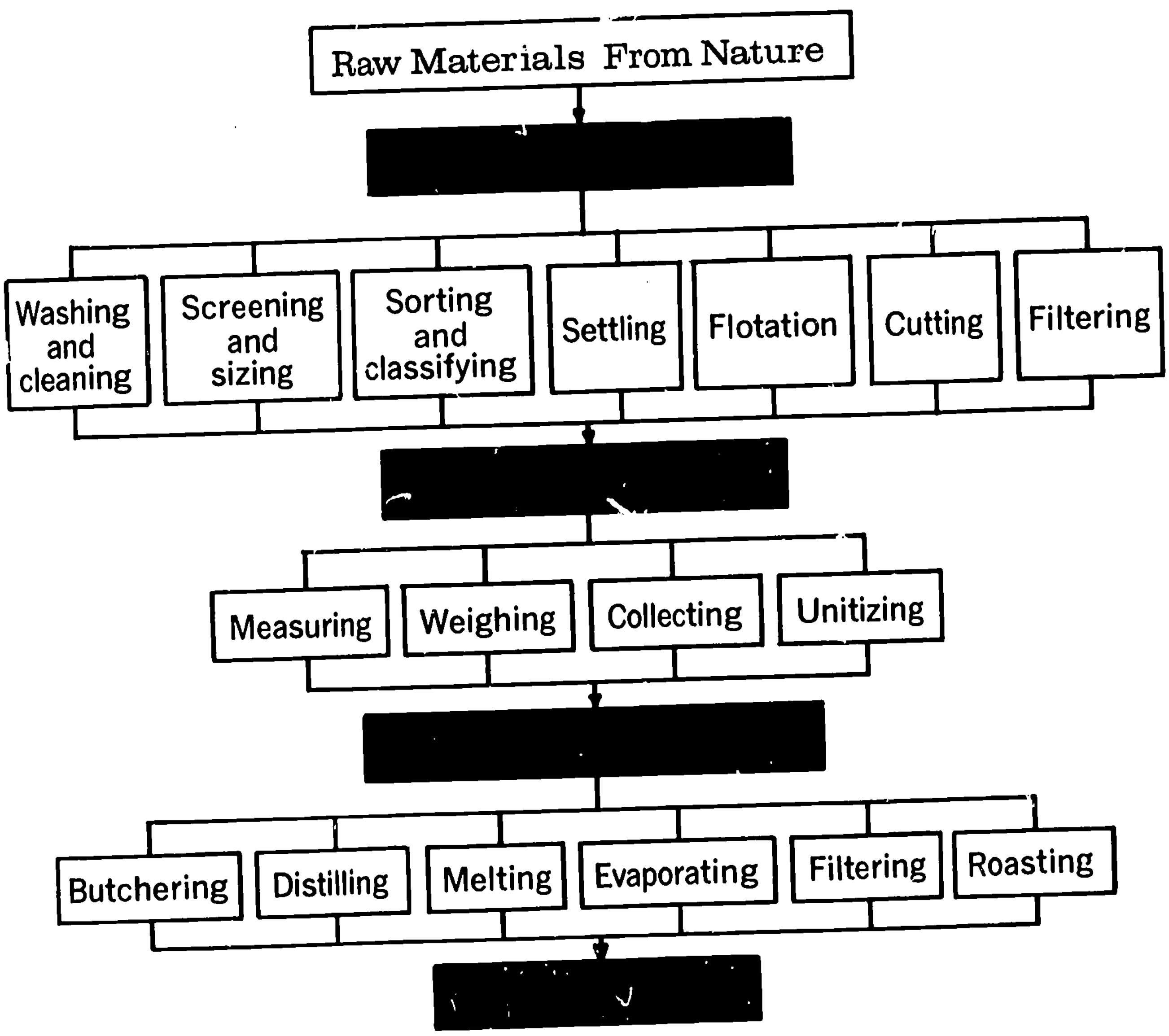
Fig. 42-9. Converting Processes in Papermaking
A. Whole pulpwood logs.
B. Logs have been converted into chips.
C. Material is converted to liquid pulp.

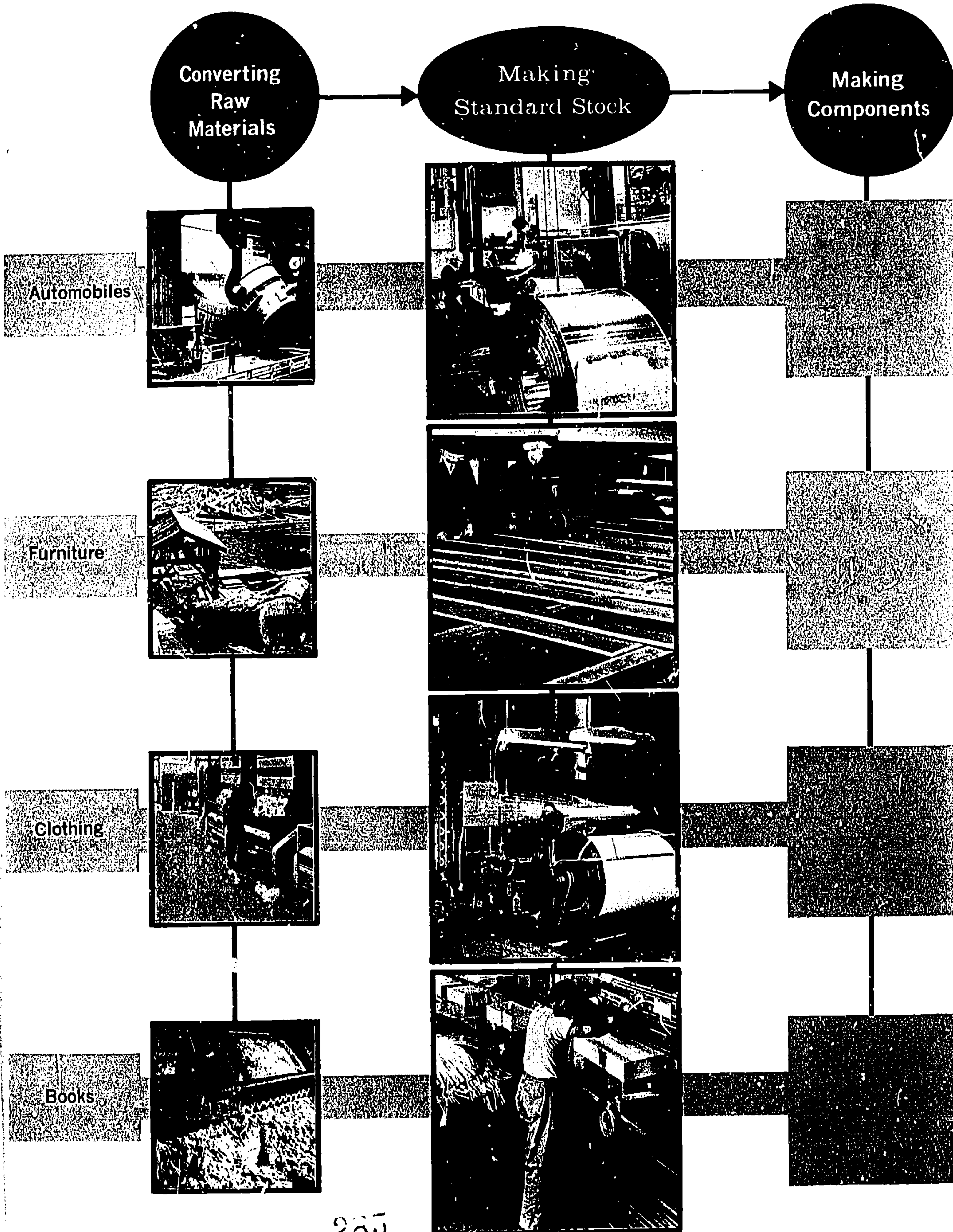
Terms to Know

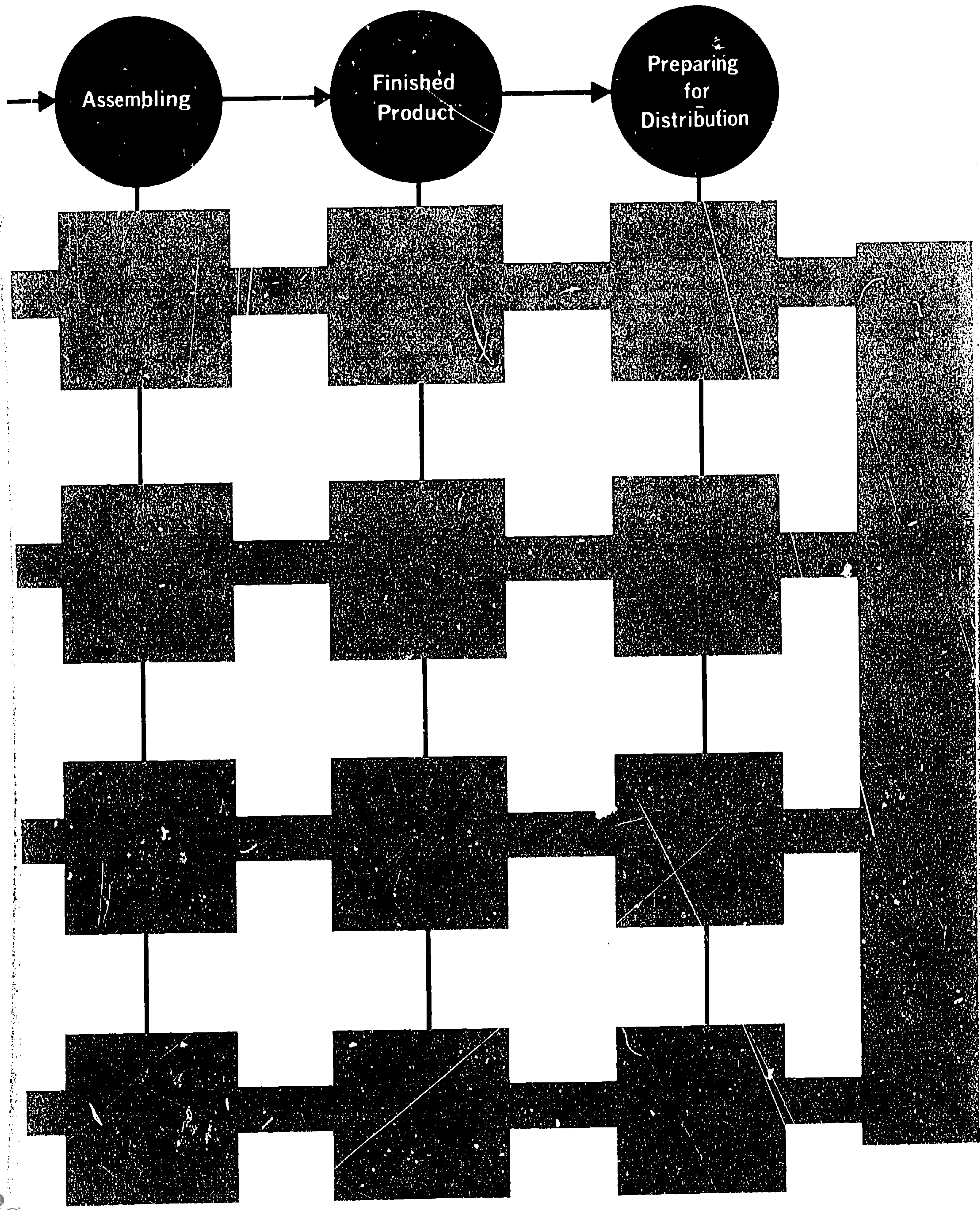
refining	bulking
bulk	measuring
by-products	weighing
waste	collecting
washing	unitizing
cleaning	storage
screening	handling
sizing	transportation
sorting	transport systems
classifying	converting
settling	ores
flotation (floating)	pulp
cutting	fiber
filtering	molten
peeling	sheetglass
stripping	pasteurized
husking	butchering
shelling	distilling
scaling	evaporate
skinning	condense
standards	melting
policies	evaporating
	roasting

Think About It!

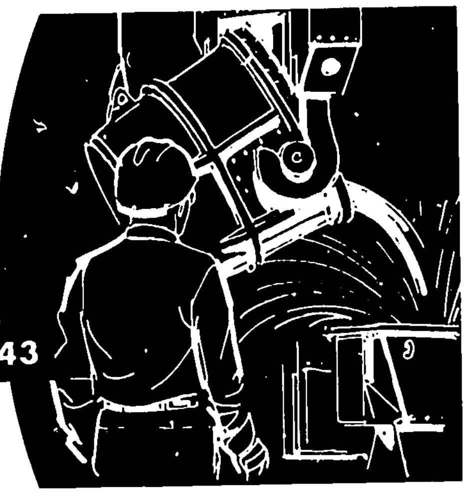
1. List some of the reproducible raw materials secured near your city.
   a. What refining processes do they go through?
   b. What quality control standards apply to these materials?
2. List some nonreproducible raw materials extracted near your city.
   a. Who buys these materials?
   b. What industrial materials can be made by converting them?


Raw Materials From Nature
Washing and cleaning
Screening and sizing
Sorting and classifying
Settling
Flotation
Cutting
Filtering
Measuring
Weighing
Collecting
Unitizing
Butchering
Distilling
Melting
Evaporating
Filtering
Roasting


Converting Raw Materials
Making Standard Stock
Making Components
Automobiles
Furniture
Clothing
Books


Assembling
Finished Product
Preparing for Distribution

READING 43



Making Industrial Materials into Standard Stock

Natural raw materials are first prepared and changed into industrial materials. Then they are processed further. Solid materials are made into standard sizes, shapes, and weights (*standard stock*). Liquids and gases are processed to get uniform (*standard stock*) properties. Standard stock becomes the "raw" material of other manufacturers. Standard industrial stock is made by a very few large manufacturers. The *capital investment* (outlay of money) is very high because of the huge and very special equipment needed. The *volume* (number of products) of production is very high also. Standard stock is used by other manufacturers to make *components* (parts) of the many products we use each day.

Examples of Standard Stock

Primary metals manufacturing plants turn out plate, sheet, tube, pipe, bar, rod, rail, and structural shapes, Fig. 43-1. These standard stock items are then used in plants where *fabrication* and *assembly* work is done. Standard stock in metals is usually formed in long pieces with *uniform* (the same) cross section within any one piece.

The capital investment in the primary metals field is very great. Recently a major steel manufacturer spent $600 million to expand his plant. You can see why only a few firms can afford to make standard stock.

Textile mills (plants that make cloth) produce bolts of broad woven cloth, narrow fabrics, felt, and other standard stock. These products are used by clothing manufacturers. Long pieces with uniform cross sections are made in textile mills also.

Lumber mills produce lumber in standard forms. Think how hard it would be to build a wood frame house with lumber from different mills that do not have standard products.

Paper mills make paper, paperboard, cardboard, and fiberboard in different standard forms. These pages and this book have been made from standard stock from paper mills, Fig. 43-2.

Producing Standard Stock

You have learned that standard stock is made in plants or mills that need costly special machines. You have also learned that standard stock pieces are usually long, with uniform cross section, Fig. 43-3. Standard stock of liquids and gases is also uniform, but it takes the form of its containers.

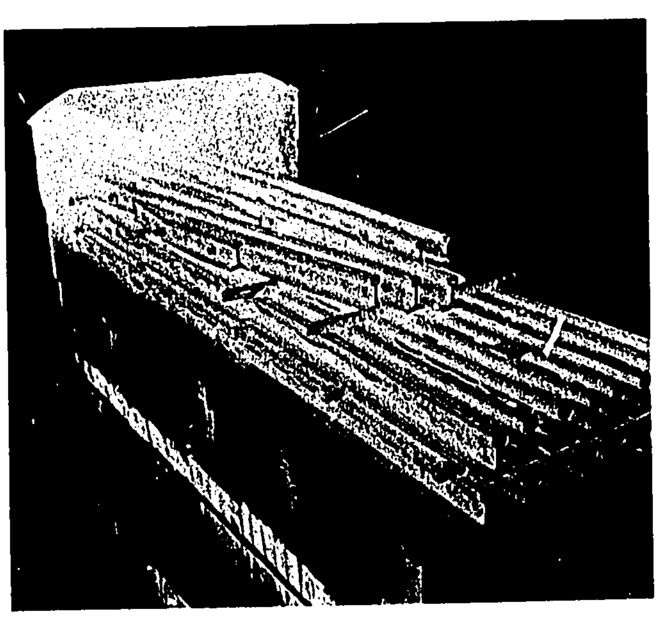


Fig. 43-1. Rails are just one form in which steel is made into standard stock by steel mills.

Some standard stock passes through rolls or similar *deformation* (form-changing) machines, Fig. 43-4. Examples are metals and glass. Other standard stock, like cloth and lumber, is processed by very different kinds of machines. Still other standard stock like chemicals, petroleum, paper pulp, and leather is processed through pipes, vats, and containers.

Standard stock is made by *continuous process*. Many of the mills that make standard stock are called *continuous (process) manufacturing* plants. They are *not* usually thought of as fabricators of end products for personal consumer use.

Some standard stock is *made to order* for large fabricating or processing companies. Some is produced because the manufacturer is sure of a steady demand for it. Product designers of end-products depend a great deal on makers of standard stock. They can plan to get such material without designing the material itself. This cuts the cost of developing products.

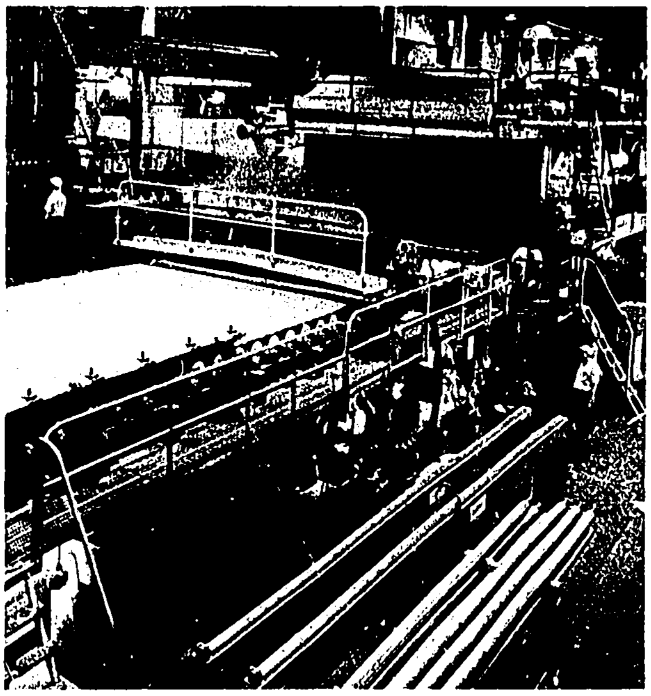


Fig. 43-2. Paper pulp is being made into a wet sheet on the Fourdrinier. The Fourdrinier is the wire screen part of a papermaking machine.

Standard Stock and Standard Parts

Standard stock almost always has to be processed further to be useful to the man on the street. Some stock is made into parts or assemblies such as transistors, shirt fronts, or bicycle tires. Some is *packaged* (put into containers); for example, milk, shoe polish, and salt.

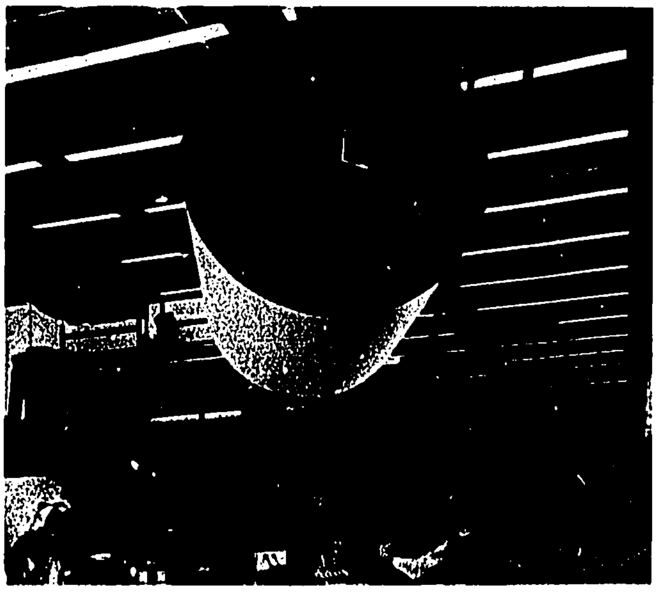


Fig. 43-3. On the "dry end" of papermaking machines, a "log" end of paper of uniform cross section and width is taken off.

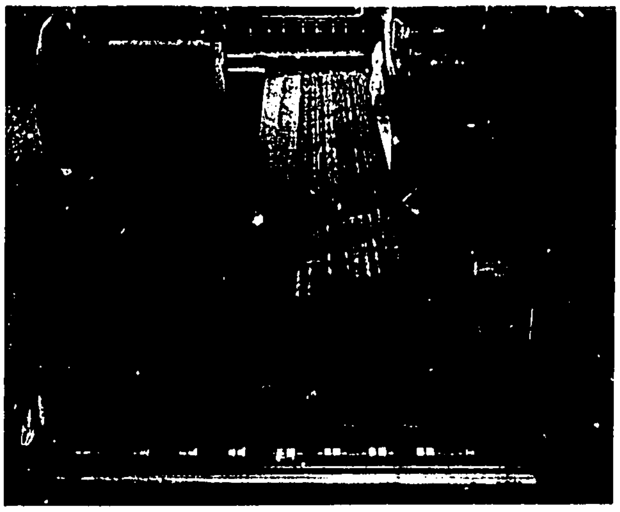


Fig. 43-4. The standard stock coils of steel (bottom of picture) come from slitting a larger standard stock coil (top of picture).

Fig. 43-5. The open bins on the left contain standard parts. *Standard parts* are combined during assembly.

Standard parts are made from standard stock, but they only need to be assembled, Fig. 43-5. You can go to the hardware store and buy nails, bolts, or washers. Sometimes these items are called *standard stock items,* instead of standard parts.

Liquids, solids, and gases from chemical and petroleum plants are used in making a large number of *end products* (finished goods). Materials are also used as *solvents* (liquids that can dissolve other substances) or *catalysts* (substances that speed up chemical reactions) in many plants.

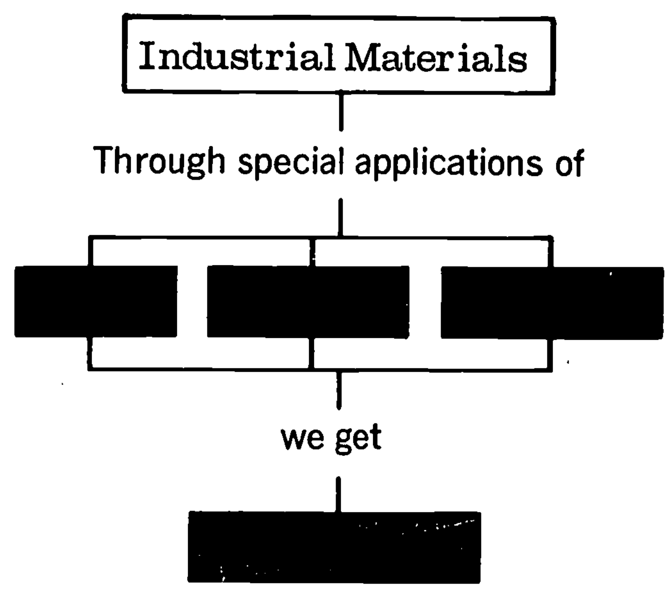
Standard stock is also made in the leather, foods, tobacco, stone, clay, and glass industries. In many cases, end products are made as the final step in some *converting* (change) process. *Standard stock items* in a store should not be confused with *standard stock* from a basic or primary industry.

Summary

Raw natural materials are prepared and converted into industrial materials. Then these industrial materials are usually made into standard stock. This kind of manufacturing needs large amounts of money for special plant buildings and machines. Standard stock is bought by other manufacturers who make this material into the thousands of manufactured products we use each day. Often the large companies that make standard stock also make some end products or finished goods. The next four readings cover in greater detail some of these activities.

Terms to Know

standard stock	continuous (process) manufacturing
capital investment	made to order
volume	packaged
components	standard parts
fabrication	standard stock items
assembly	end products
uniform	solvents
textile mills	catalysts
deformation	converting
continuous process	



Think About It!

1. What would you have to do if you were building a wooden bench with lumber from mills that had not *standardized* their stock?
2. What kinds of *standard stock* were used in the manufacture of your shoes? your shirt? your kitchen chairs?

READING 44

Story of Primary Metal Products

The next four readings will outline broadly some of our largest industries. They are often called *primary industries* because they do the *first* processing of raw materials. After primary industries change raw materials into standard stock, other manufacturers process the stock further to make *end (finished) products*, Fig. 44-1.

In each of these industries, look for the management jobs of research, product development, process planning, and process controlling. Look also for the jobs which *obtain* the raw materials from nature, *refine* and *bulk* these materials, *convert* them to industrial material, and *form* them into standard stock.

The Primary Metals Industry

Metals are very important to modern industrial countries. Many of the products used in homes, offices, and schools are made mostly of metals, Fig. 44-2. The tools and machines used to produce other metal products, chemicals, petroleum products, textiles, wood products, plastics, and agricultural goods are also made largely of metals.

This reading will deal with the mining and processing of metals: *extracting, refining,* and *converting* ores, together with *preliminary* (beginning) *shaping* operations. The output is usually standard stock. This in turn becomes the "raw" material for other metals manufacturers.

Raw Materials

Chemists and physicists have shown that all materials are made up of *elements*. There are about a hundred different elements. In most materials in nature, there are several elements in combination. Metals are most

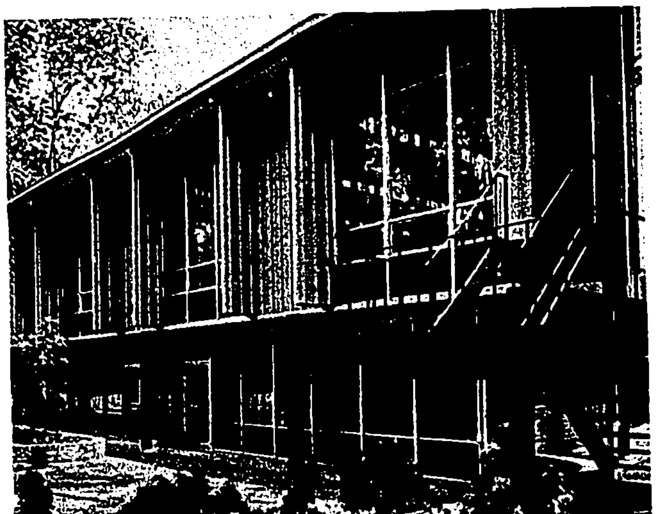


Fig. 44-1. Primary metals were used in the construction of this modern building.

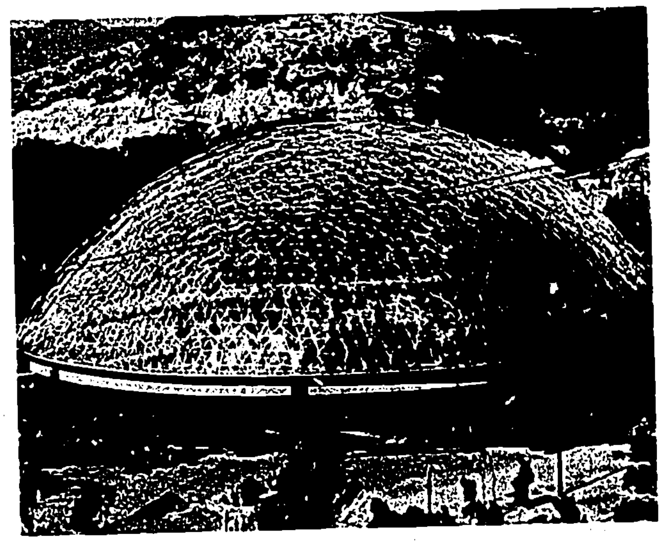


Fig. 44-2. This is an example of a geodesic dome designed and built of aluminum.

230

useful to industry as pure, or nearly pure, elements. Two pure metals can be combined to form another useful material called an *alloy*.

The large amounts of pure metals produced today come from metal *ores*. These ores are compounds of metals and other elements, usually oxygen or sulphur. The *iron ores* are compounds of iron and oxygen (iron oxide). Some of these iron ores have special names such as "hematite," "limonite," or "taconite." *Copper* is found in nature combined with sulphur. In a handful of common dirt or clay there is a large percentage of *aluminum*. Aluminum is found combined with silicon and oxygen. Seawater is the source of *magnesium* compounds.

To process the metal ore, other raw materials are needed for primary metals production. Iron and steel need large amounts of coal, limestone, water, and oxygen, Figs. 44-3 and 44-4. Aluminum refining needs large amounts of electrical energy.

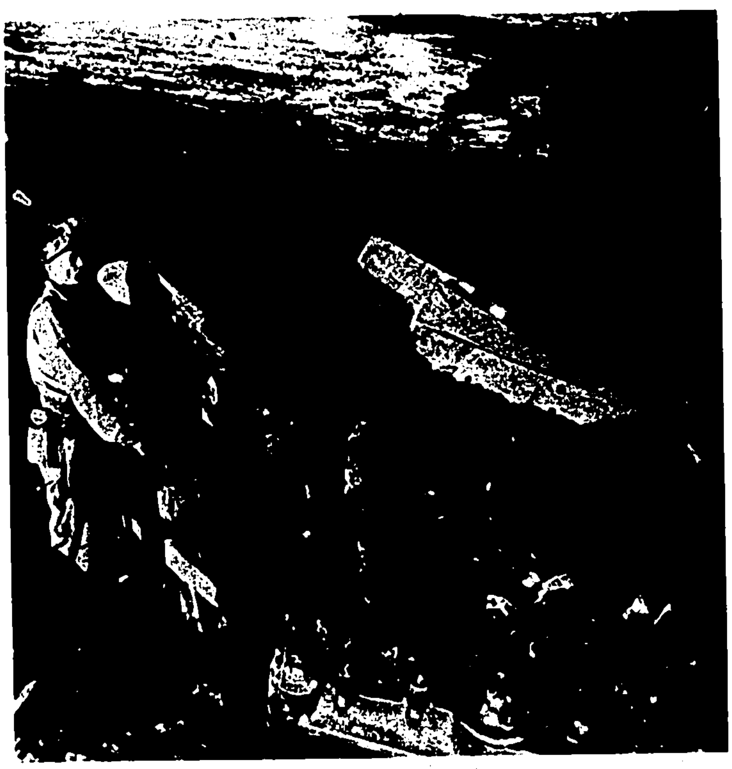


Fig. 44-3. The coal taken from this mine will be fed into a blast furnace to help make iron and steel.

Primary Metal Products

These raw materials are then made into standard metal stock. The most important products are sheet and strip, plate, bar, rod, wire, tube, pipe, structural shapes, and rails. Metal stock usually is made with *standard dimensions* (cross sections, thicknesses, and lengths). It is called *standard stock.*

Primary Metal Processing

Primary metals processing is divided into three steps. These steps are (1) refining the ore, (2) converting it to pure metals and alloys, and (3) forming it into standard stock.

There are more than 70 metallic elements. About 40 of these are processed by industries. Only nine are processed in large amounts for use as pure metals or as the main metal in an alloy. Other metals are refined mainly for plating or alloying with other metals.

Most metal ores are gotten by mining. They are usually obtained by *open-pit operations*. However, magnesium is converted from seawater. Some refining of the ore

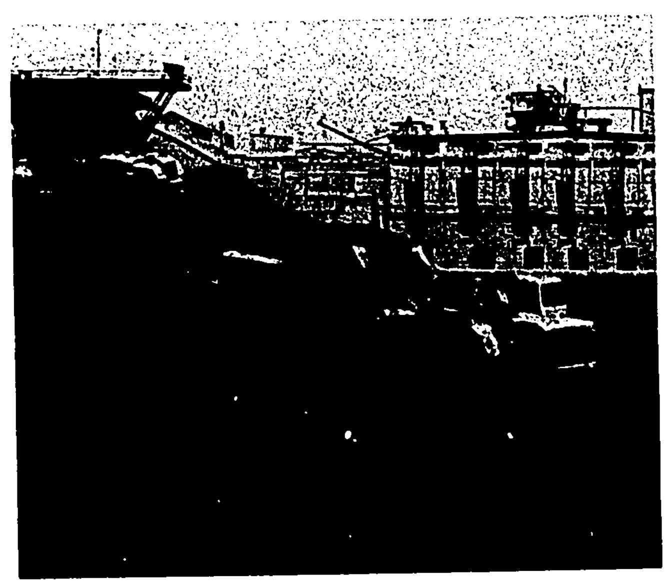


Fig. 44-4. This coke is on its way to the blast furnace to help make iron and steel.

may be needed to take out unwanted minerals called *gangue* (pronounced like *gang*).

After extraction and refining, most ores are metal oxides. Copper ore (copper sulphide) is *roasted* to produce copper oxide. (Sulphuric acid is an important *by-product* of this roasting process.)

Metal oxide usually is changed to pure metal by a chemical process called *reducing.* Most metals are reduced in a blast furnace. The ore, limestone, and coal or coke are put into the top of a tall cylindrical stack. Air for burning the coal or coke comes into the stack near the bottom. Part of the carbon in the coal or coke combines with the oxygen in the ore. The metal in the ore collects as a liquid in the bottom of the stack. The limestone melts and forms a *slag* (rough hard waste) on the surface of the metal. Many impurities like gangue dissolve in the limestone and the ash from the coal or coke. Many by-products come from this process.

Fig. 44-5. Molten iron rushes from a blast furnace through a series of clay-lined runners into a "submarine" that is used to transport the molten metal.

Aluminum is changed by a different process called *electrolysis* (passing electricity through a special liquid). Sometimes electrolysis is also used for *purifying* (improving the purity of) copper and some other metals.

Iron and steel account for about 90 percent of the tonnage of all metals produced. As *molten* (melted) iron comes from the blast furnace, it contains carbon and silicon in dissolved form, Fig. 44-5. It becomes solid in its crude form (*pig iron*).

The pig iron is used to make *castings* (cast iron, gray iron, malleable iron). But iron with too much carbon is too brittle to be forged, rolled, or put through other *deformation* (form-changing) processes.

The carbon and silicon may be taken out of the pig iron in an open-hearth furnace, an electric furnace, or by a new process that uses a basic oxygen furnace, Fig. 44-6. The product that comes from any of these furnaces is purer than the iron from the blast furnace. It is now called *steel.* Some carbon is left in to give the steel greater strength

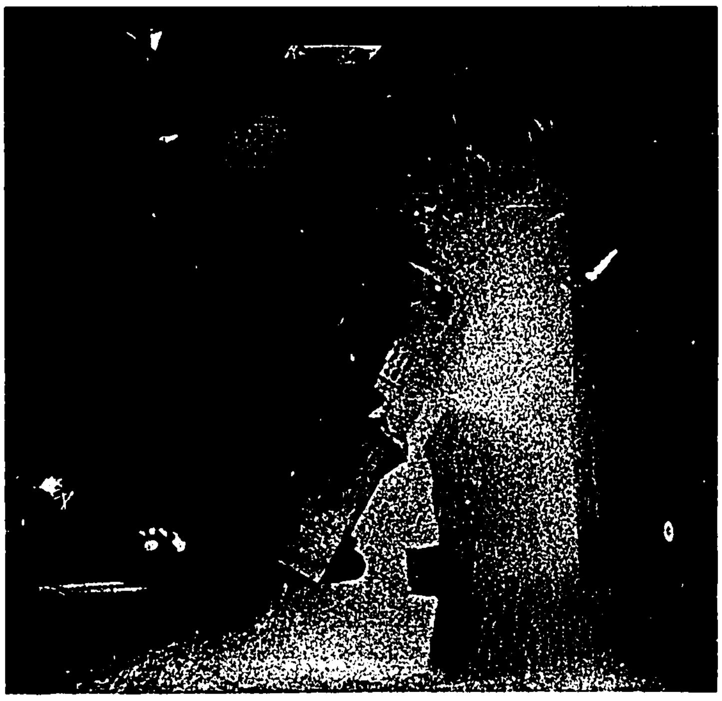


Fig. 44-6. Hot pig iron from the blast furnace is being poured into an open-hearth furnace.

than pure iron. Most steel is then cast to make *ingots*, Figs. 44-7 and 44-8.

Ingots of steel or other metals are made into standard stock by *deformation* processing. *Hot rolling* is done by passing a red-hot ingot between rollers. These rollers are set closer together than the thickness of the ingot, Figs. 44-9 and 44-10. After passing between several sets of rollers, the ingot is called a *bloom* or a *slab*, Fig. 44-11. *Slabs* are further rolled to make plate and sheet. *Blooms* are further rolled to make billets, bars, and rods. *Billets* are further rolled or *drawn* to make structural shapes or wire.

Some metals can be shaped by *extruding*. The hot metal is forced through a shaped hole (*die*) in much the same way as toothpaste is squeezed from a tube. This process is most important for aluminum and copper.

Most sheet steel is *finished* by *cold rolling*. This makes better surface finish and sheets with more correct dimensions than hot rolling, Fig. 44-12. Much of the sheet steel also is *plated* with zinc, aluminum, or lead so that it won't *corrode* (wear away).

Fig. 44-7. A ladle of molten steel, hot from an open-hearth furnace, is being poured into ingot molds.

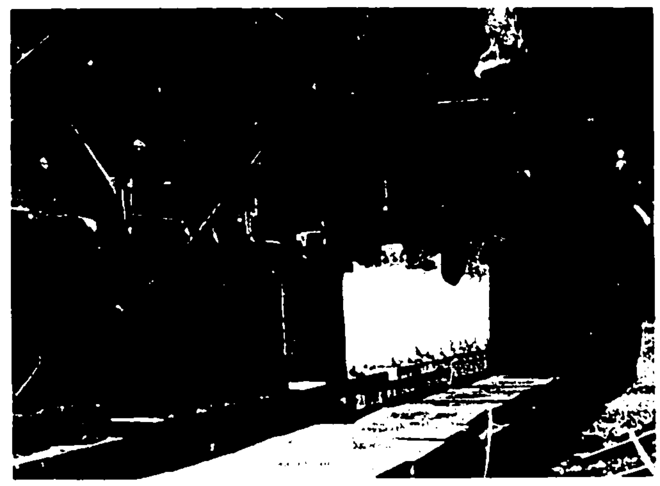


Fig. 44-8. Molds are stripped from the ingots.

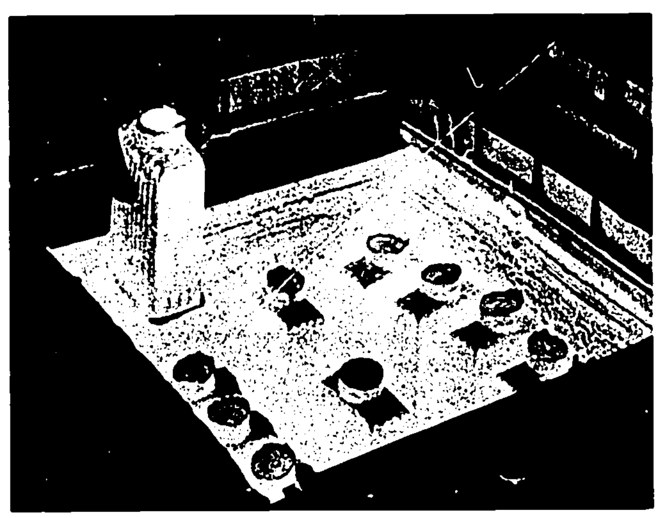


Fig. 44-9. Ingots are reheated at about 2200°F. in a soaking pit. They are kept at that temperature from four to eight hours to heat them all to the same temperature.

Fig. 44-10. A hot steel ingot is put into place in the blooming mill.

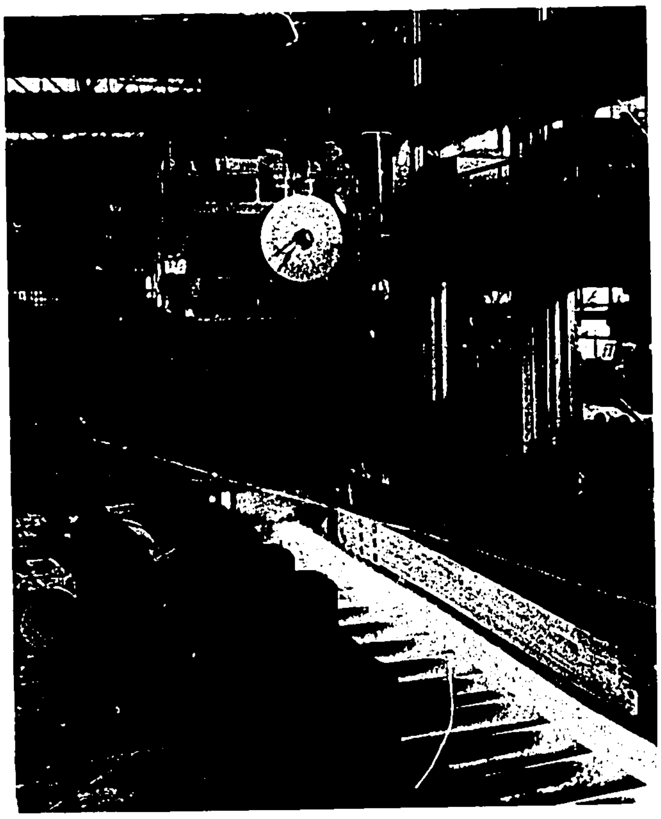


Fig. 44-11. An ingot is being rolled into a bloom in a blooming mill.

Product Design and Development

Iron and steel are produced in large quantities because they are strong metals. Ores are plentiful, and converting and shaping these ores is not too hard to do. Other metals are harder to get and to process.

Product designers in other industries and engineers in primary metals have done a lot for each other. Most standard stock is made to meet the needs of other industries, Fig. 44-13. The primary metals engineers have made many new standard stock forms. These new forms in turn have led to new products. One of the newest of these in *steel foil.*

The primary metals industry does a great deal of research to develop new alloys. Alloys often make new products possible. Jet engines and space capsules could not have been built without alloys developed in the last 25 years.

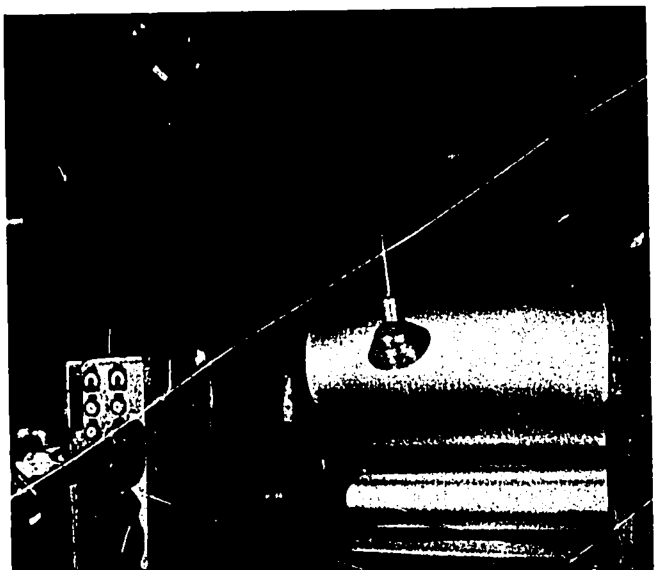


Fig. 44-12. This machine is cold-rolling steel sheets.

Fig. 44-13. These are rolls of sheet steel in storage ready for use.

Process Engineering

Most process developments have tried to cut down costs or improve quality. The steel made today is like the steel made 700 years ago. At that time only kings could afford metal products. Today in the United States, enough steel is made each year to give each person in the country more than 1000 pounds.

Titanium is becoming an important metal because improved processing has been made cheaper. There is plenty of titanium ore, but it could not be converted cheaply until recently. It took the combined efforts of chemists, electrical engineers, *metallurgists* (people who study the separation of metals from their ores), and industrial engineers to find a cheap conversion process for this ore.

In the United States, the steel industry is now processing low-grade taconite ores. These ores have only about 25 percent iron oxide in them. New ways have been developed to refine and *pelletize* (make into small particles) the ores. Without these new methods, the cost of steel would be much higher.

Engineers have also developed many new ideas for process control. For example, as sheet metal is rolled, the thickness is constantly measured by a *beta-ray gage*. The output of this gage controls the spacing between the rollers.

Fig. 44-14. Trained employees keep a watchful eye on the steel as it is made.

Fig. 44-15. An inspector checks 4" flats on the cooling bed to see how precisely they have been made.

Personnel

There are still some unskilled jobs in the primary metals industry, but most workers are at the semiskilled, skilled, or professional level. Semiskilled workers include maintenance men, machine operators, and inspectors, Figs. 44-14 and 44-15. Skilled workers include rolling-mill operators, laboratory technicians, and toolmakers. Professional workers include chemists, metallurgists, and engineers.

Summary

The primary metals industry is very important. Raw materials (*ores*) are mined, refined, and converted to produce pure metals. Research and development have come up with new alloys, processes, and products. Costs have been cut down, and quality has improved. Most converting operations are done at steel plants where rolling, forging, and other deformation operations are used to make standard stock forms. These include

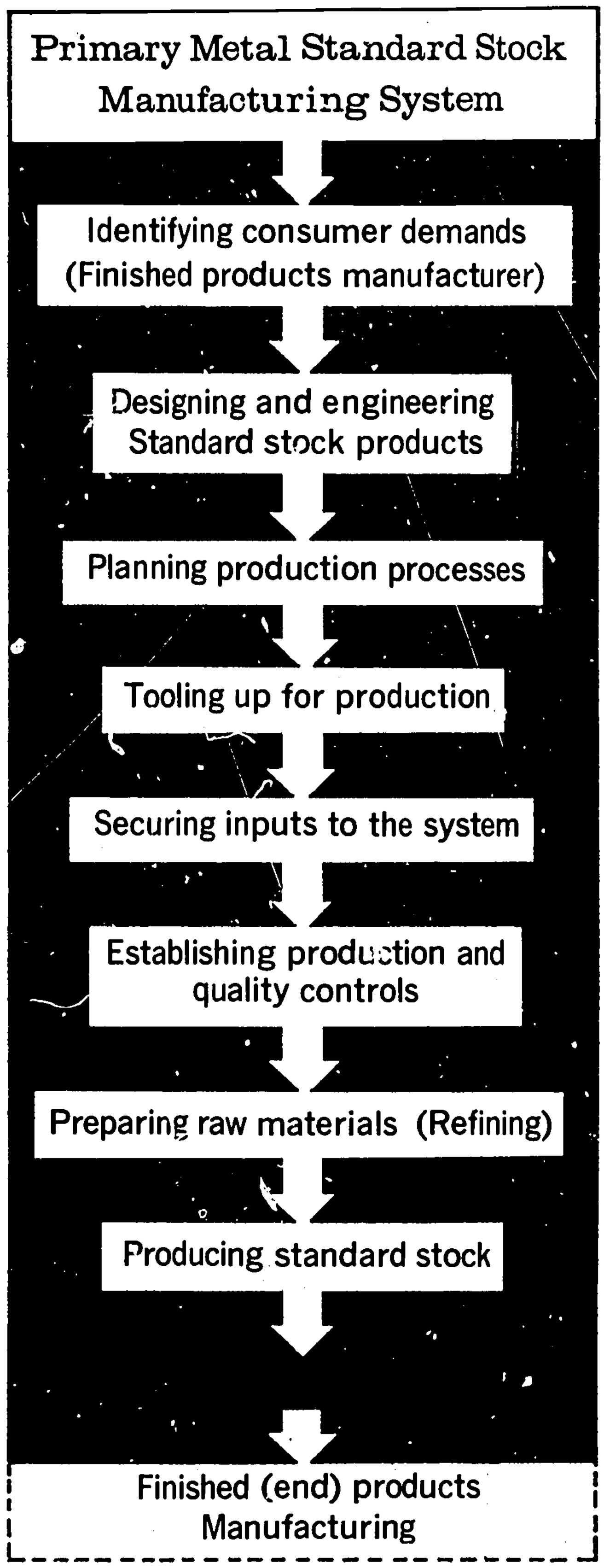
bar, rod, wire, pipe, sheet, plate, and structural shapes. Iron and steel are the most important of all the metals.

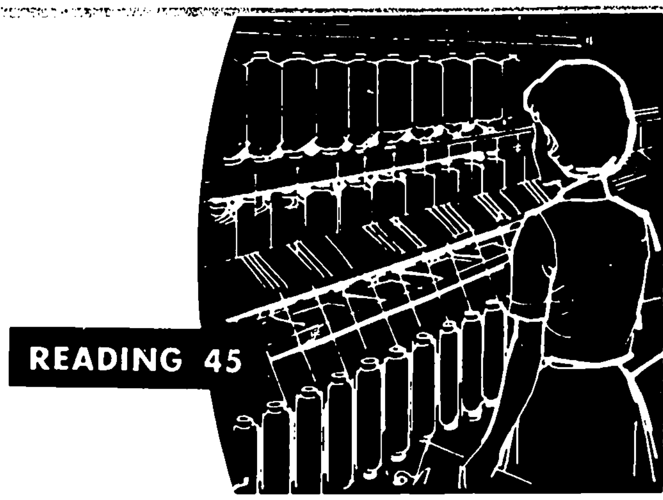
Terms to Know

primary industries
end- (finished) products
obtain
refine
bulk
convert
form
extracting
refining
converting
preliminary
shaping
elements
alloy
ores
iron ores
copper
aluminum
magnesium
standard dimensions
standard stock
open-pit operations
gangue
roasted
by-product
reducing
slag
electrolysis
purifying
molten
pig iron
castings
deformation
steel
ingots
hot rolling
bloom
slab
billets
drawn
extruding
die
finished
cold rolling
plated
corrode
titanium
metallurgists
pelletize
beta-ray gage
steel foil
research and development

Think About It!

1. How do you think product designers help in the making of *steel foil?*
2. Why are *research and development* personnel important to the iron and steel industry?





Story of Textile Mill Products

Textile (cloth) mill products are one kind of standard stock made by a *primary* (basic) industry for other industries. Textiles contribute to man's clothing, shelter, and transportation as well as to his luxuries. Because textiles are used in so many ways, they are very important. This reading will show how these common but very important products are made.

The Textile Mill Industry

Textiles are made in about 7,500 mills in 42 states. More than half of America's textile mills are in North and South Carolina. Many more are in Alabama, Georgia, Tennessee, Virginia, Texas, and the New England states. Some of these mills make cloth and then turn it into an end-product like towels or sheets. Most mills make only yarn or cloth in standard lengths and sizes. American mills make cloth at a rate of nearly 15 miles per minute. This is about 15 billion square yards of cloth per year. This is enough cloth to wrap a strip one yard wide around the earth 340 times.

Raw Materials

Textile manufacturing starts with *fibers.* For hundreds of years the fibers used were *wool* and *cotton,* and sometimes *flax* and *silk.* Today about one-half the fiber used for textile products is cotton, Figs. 45-1 and 45-2. Man-made (*synthetic*) fibers run second. *Wool* accounts for five percent and *silk* less than one percent.

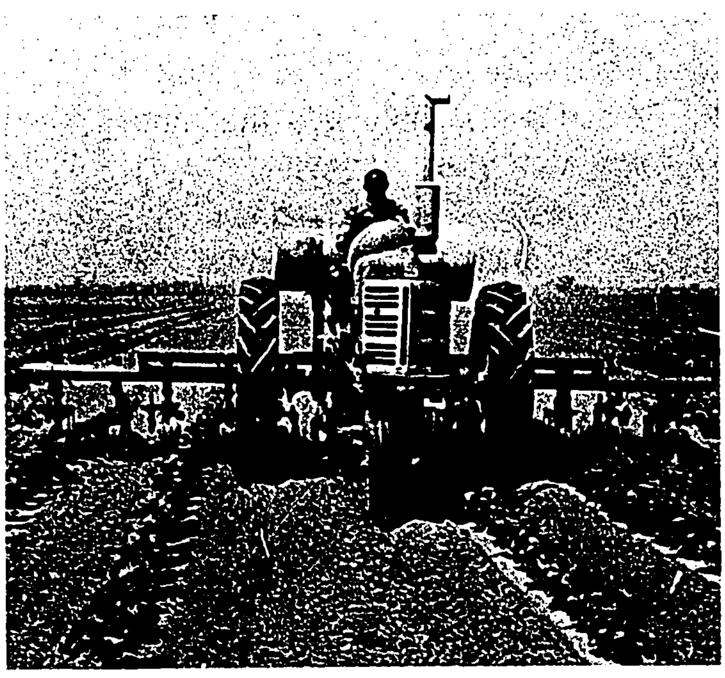


Fig. 45-1. This farmer is raising young cotton plants.

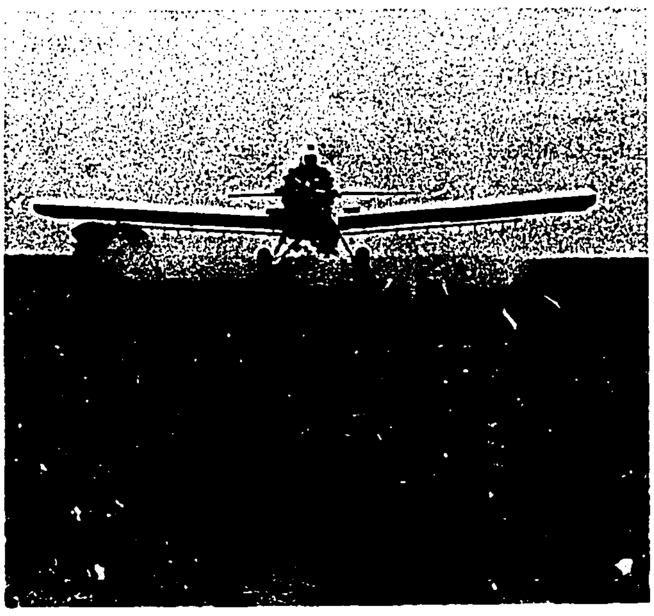


Fig. 45-2. Cotton is sprayed with insecticides to get more and better cotton.

Cotton grows in the southern and western states, Fig. 45-3 and 45-4. The cotton *boll* is picked from the cotton plant by hand or by automatic cotton pickers, Figs. 45-5 and 45-6. Then the cotton goes to the *gin* where the

Fig. 45-3. Cotton blossoms.

Fig. 45-4. This is the cotton boll before opening (left) and after opening (right).

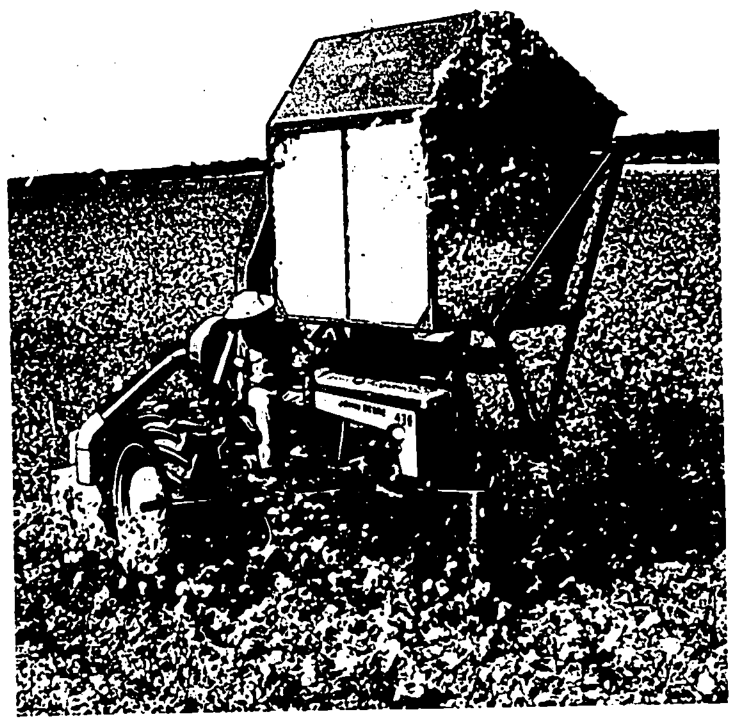


Fig. 45-5. This cotton is ready for harvest. It is picked by a cotton picker.

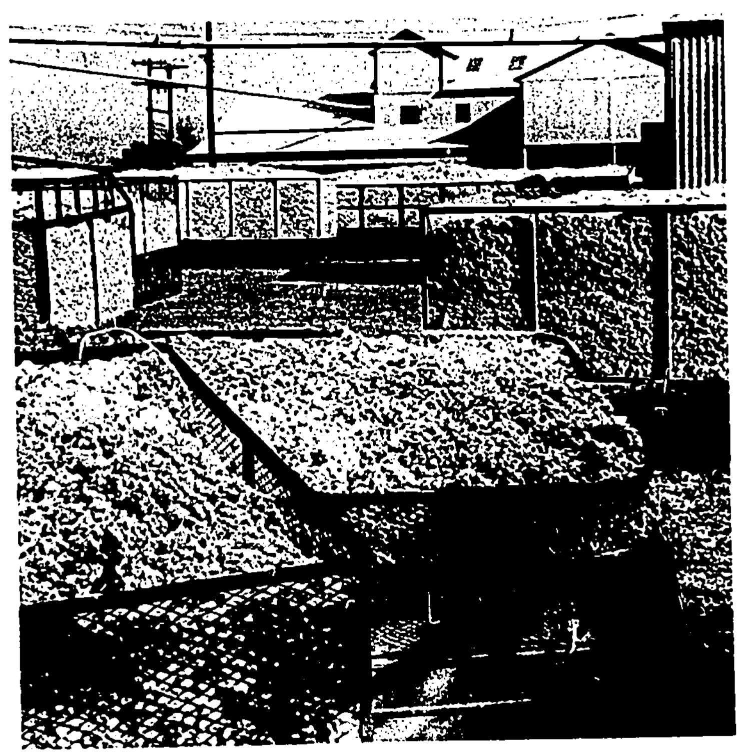


Fig. 45-6. This cotton is ready for the ginning operation.

seeds are removed. Next it is packed into 500-pound *bales* for shipment to the textile mills, Fig. 45-7 and 45-8.

Natural fibers are harvested from plants or animals. Synthetic fibers are man-made by chemical processes. These fibers may be made from wood pulp, oil, coal, glass, or other chemicals. The fibers are made by forcing liquid through holes in a nozzle called a *spinneret*. They may be made as *filament* (continuous fiber), or as *staple* (cut into lengths). Man-made fibers are usually blended with cotton or other natural or man-made fibers. This blend of fibers is better than either fiber alone.

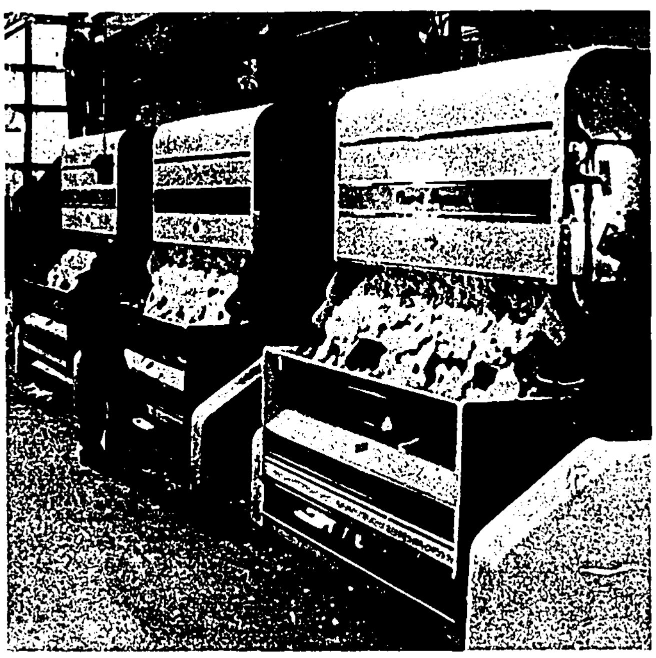


Fig. 45-7. This machine separates cotton fibers from the seeds in ginning cotton.

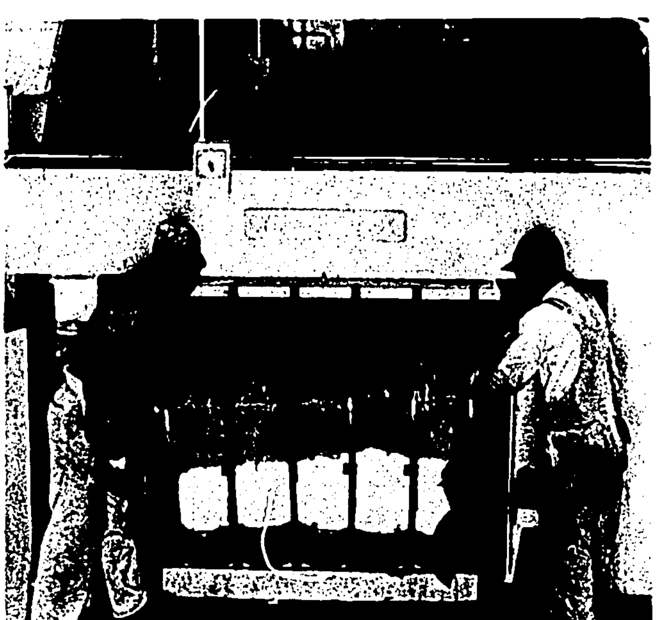


Fig. 45-8. Cotton is packed into bales for shipment.

Textile Products

Products of the textile mill include *yarn* and *cloth* in the form of standard stock. The cloth is made by *weaving* (blending fibers together). The cloth may be broad-woven or narrow-woven. Textile mill products may also be knitted. Most products of knitting mills are finished products like hosiery.

Textiles are made into thousands of kinds of finished products. The clothing that people wear is made from textiles. Much of the furniture coverings used in homes are also made from textiles. In an automobile, textiles are used for the upholstery, the inside top lining, the inner cord of the tires, the carpeting, the water hose, and the covering for electric wires. Industry uses textiles for conveyor belts; pipelines and storage tanks for oil and other liquids; heavy-duty belts for machinery; filters for chemicals; tarpaulins; uniforms; helmets; and footwear. The space program uses textiles for the astronauts' suits and parachutes. The military must have uniforms, bedding, tents, truck covers, life rafts, bulletproof vests, flags, fire hose, and parachutes.

If you look around, you will see many other uses for textiles. Awnings on houses, raincoats, golf bags, gun cases, book bags, book bindings, and the American flag are all textile products.

Processing

There are many steps in making raw fiber into cloth. We will follow these steps through a textile mill.

The first takes place in the opening room. Here bales of cotton or other fibers are opened and placed in the opening machine, Fig. 45-9. This machine fluffs the fibers, removes dirt, and blends two or more kinds of fiber. The fibers come from the opening machine in small fluffs. These are carried by air to a machine called a *picker*. The picker beats the fibers to clean them further. Then it forms them into a uniform sheet called a *picker lap*, Fig. 45-10. Then the *card machine* combs the fibers and forms them into a web. The web is rolled into a ropelike *strand* called a *sliver*, Fig. 45-11.

Strands of sliver are fed into a drawing frame which draws and stretches the fibers and makes them *parallel* (side-by-side). It then forms many strands of sliver into one strand, Fig. 45-12. These are fed into a *rib-*

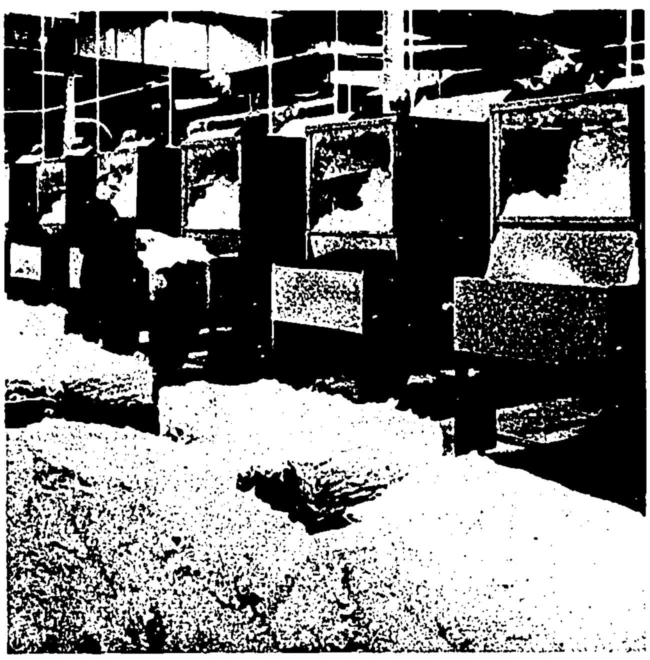


Fig. 45-9. At the textile mill the bales of cotton are opened and placed in these opening machines.

Fig. 45-10. A cleaning machine called a *picker* cleans and makes a uniform sheet of picker lap.

Fig. 45-11. This carding machine combs the cotton fibers and forms them into a strand.

Fig. 45-12. These strands of sliver are going into a drawing frame. This operation forms strands of sliver into one strand and makes the strands parallel.

bon lap machine. It combines strands of sliver into a ribbon lap and winds it into a roll. Eight rolls of ribbon lap are fed into a *comber*. It combs out the short fibers and makes the long fibers parallel, Fig. 45-13. On the *roving frame* the fibers are then reduced in size and given a slight twist for strength, Fig. 45-14. Finally, on the *spinning frame* the fibers are stretched further. Then they are twisted 10 to 30 turns per inch to form yarn. The yarn is wound on *bobbins*, Fig. 45-15.

Even after this long process, the yarn is not ready to be made into cloth. The bobbins of yarn must go to a *spooler*. Here they are wound onto *cheeses* to form a package of yarn. The cheeses go to a *warper*. Here hundreds of separate strands are wound onto a large spool called a *beam*. The beams go to a *slashing machine*. Here the yarn is treated with a hot solution of starch, wax, oils, and water to strengthen it. It then travels over hot pressurized cans for drying. Finally, it is wound onto a huge beam or roll.

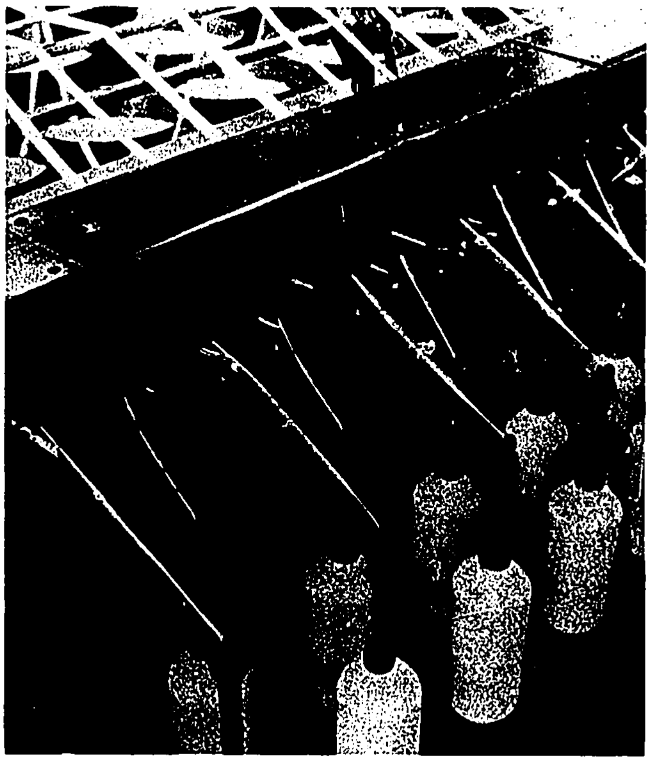


Fig. 45-14. On this roving frame, single slivers are passed between a series of rollers. They are greatly reduced in size and then wound on bobbins.

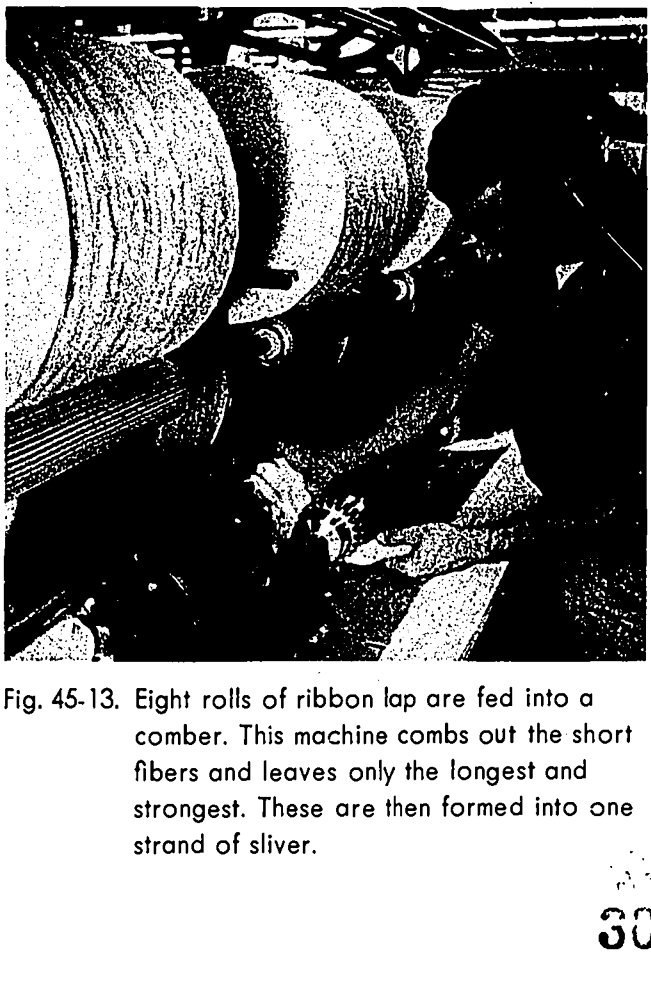


Fig. 45-13. Eight rolls of ribbon lap are fed into a comber. This machine combs out the short fibers and leaves only the longest and strongest. These are then formed into one strand of sliver.

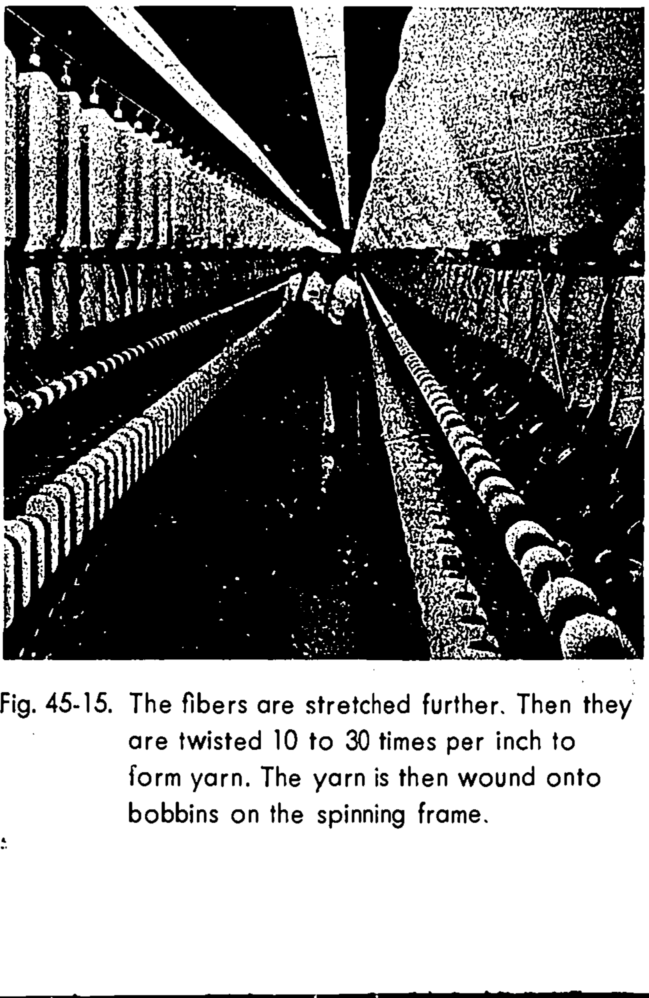


Fig. 45-15. The fibers are stretched further. Then they are twisted 10 to 30 times per inch to form yarn. The yarn is then wound onto bobbins on the spinning frame.

At last the yarn is ready to be woven into cloth, Fig. 45-16. The most common kinds of cloth are woven on a *shuttleless loom*. Complicated patterns are woven on a *jacquard loom*. Carpets and bedspreads are made on special *tufting machines*. Much of the yarn is processed by *knitting machines* to make goods like undershirts and hosiery.

Although the cloth is now woven, it must still be finished. It is first washed and *bleached* (made white). Some of it is then *dyed* solid colors. Some of it is printed with different patterns. Usually the cloth is then processed so it will not shrink when it is washed.

Research and Development

The textile industry is always working to develop new methods, finishes, and products. Teams of research scientists work in laboratories trying out new ideas. They have developed synthetic fibers and stretch yarns. Recently, scientists have learned that nuclear radiation is useful in making cloth that will not rot and mildew.

The choice of new colors, patterns, and designs for cloth is also important. New dyes are always being developed and tested. Thousands of designs are drawn each year. Of these, only the finest are picked to go into the product that will be sold to the customer.

Process Engineering

Process engineering plans and controls the different processing steps. It also tests the end-product to see if it is as good as it should be. Electronic computers are used for their speed and efficiency. For example, the electronic color-mixture computer picks out the right combination of colors. The *digital fibrograph* measures length and *uniformity* (sameness) of fibers.

Personnel

Nearly a million people work in textile mills. Some workers are unskilled, like those who move and open bales. Many are semiskilled workers, like those who run the many machines and looms, Fig. 45-17. Others are

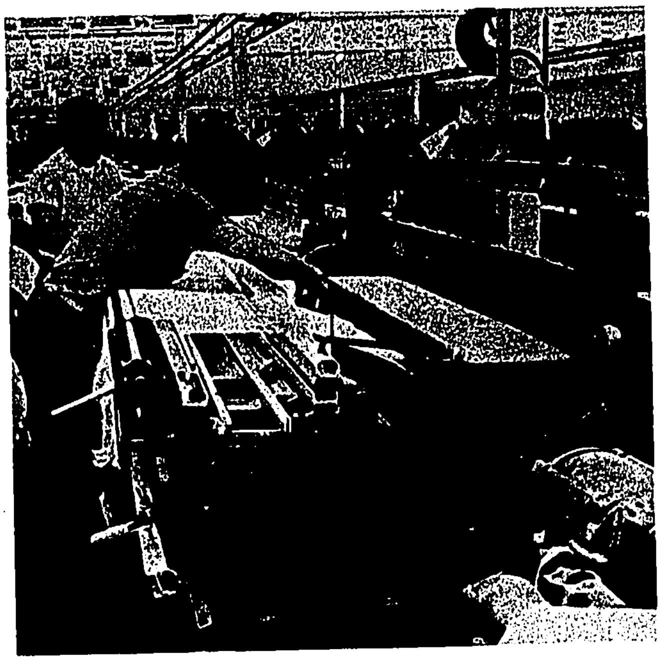


Fig. 45-16. In the weaving room, looms make cloth from yarn.

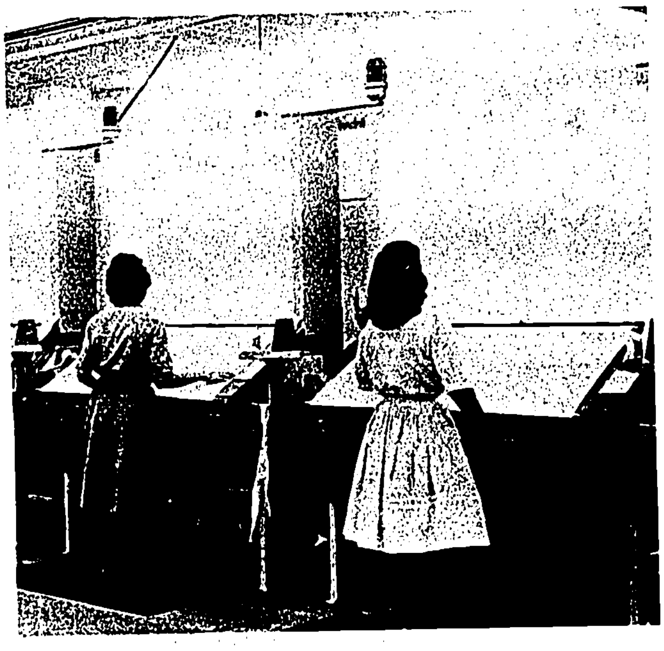
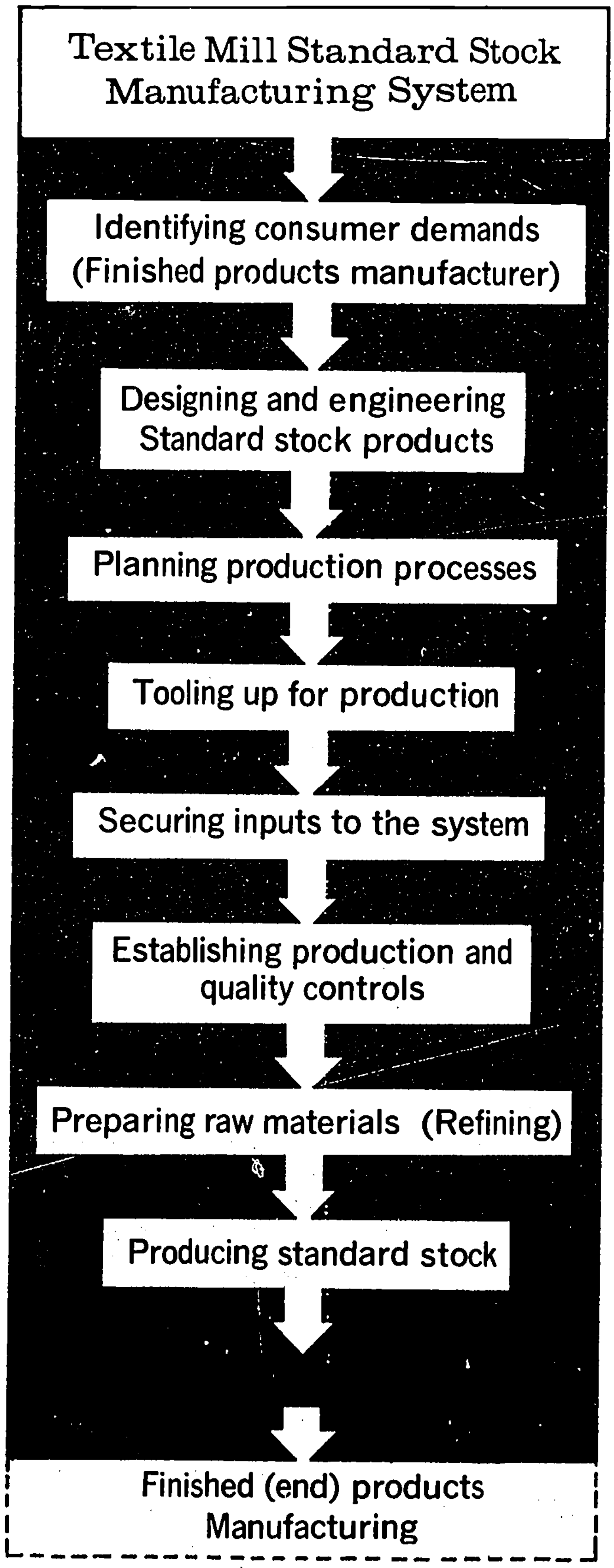


Fig. 45-17. These women are inspecting the finished cotton cloth.

creative, like those who design patterns or conduct research. Some are management personnel who oversee the many processes or work with computer data.

Since the textile industry grows every year, the need for workers is always growing. Many plants have training programs for workers. Training in management and in textile science and technology is carried on at special textile schools.



Summary

Most textile mills are located in the southeastern United States and in the New England states. About one-half of the fiber used for textile products is cotton. Man-made (synthetic) fibers run second. Textile fibers are a basic kind of standard stock.

New processes and new products that were not known even ten years ago are now common. Clearly, textile mill products are necessary for comfort and health in everything we do.

Terms to Know

textile
primary
fibers
wool
cotton
flax
silk
synthetic
boll
gin
bales
spinneret
filament
staple
yarn
cloth
weaving
picker
picker lap
card machine
strand
sliver
parallel
ribbon lap
comber
roving frame
spinning frame
bobbins
spooler
cheeses
warper
beam
slashing machine
shuttleless loom
jacquard loom
tufting machines
knitting machines
bleached
dyed
digital fibrograph
uniformity

Think About It!

1. Why do you suppose that nearly half of America's textile mills are located in North and South Carolina?

2. How many textile products do you have in your home? How many of them are natural fiber products? How many are *synthetic?*

READING 46

Story of Petroleum Products

Petroleum is one of man's most important sources of fuel. It is also very important as a raw material in making many other products. Chemical companies, drug manufacturers, and many other manufacturers use petroleum products as raw materials. In this reading you will learn about the nature and origin of petroleum and about the kinds of products that are made from petroleum. You will learn how petroleum is found, extracted, transported, and refined. You will learn about research and development and other jobs open in the petroleum industry.

Crude Oil—the Raw Material

The word *petroleum* means rock oil. Liquid petroleum was first given this name. Petroleum is found in the rocks of the earth as a *gas*, a *liquid*, and a *semisolid*. Liquid petroleum is called *crude oil*. It is the most important form. Petroleum gas is called *natural gas*. The semisolid forms are known as *asphalt* or *pitch*.

Crude oils differ a lot in their makeup, color, *viscosity* (thickness), and other features. A crude oil is really a mixture of several oils. Each oil is a slightly different hydrogen-and-carbon compound. There may also be small amounts of nitrogen, oxygen, carbon dioxide, and sulphur in crude oil.

Origin of Petroleum

The crude oil and natural gas found today were formed millions of years ago. In past ages, much of what today is dry land was covered by the oceans. Plants living in these oceans got their energy from the sun. These plants served as food for the animal life of the sea. As the small animals died, they settled to the ocean bottom and lay there until fine dirt covered them. Bacteria changed the animal remains (organic matter) into fatty, waxy, and gas-like substances. As more *sediment* (fine dirt) collected, the droplets of oil and bubbles of gas were squeezed into *porous* rock (filled with tiny holes) such as sandstone. This is where collections of oil and gas are found today.

Petroleum Products

As many as half-a-million different *molecules* (smallest parts of chemical compounds) may be separated or made from natural gas and crude oil. Each of these molecules may be used to make some kind of

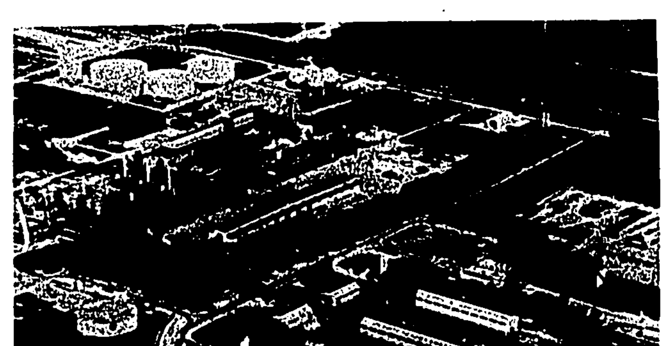


Fig. 46-1. This petrochemical plant changes and refines raw materials into more usable products.

product. Thus the importance of petroleum as a raw material can easily be seen. In the United States, about 85 percent of all crude oil processed by refineries is made into fuels like gasoline, liquefied gas, diesel fuel, coke, fuel oil, jet fuel, and kerosene. The other 15 percent is used for chemical raw materials, carbon black, lubricants, waxes, asphalts, petroleum jelly, and solvents. The chemical raw materials (*petrochemicals*) are "building blocks" used to make synthetic rubber, insecticides, plastics, detergents, synthetic fibers, drugs, and many other products, Fig. 46-1.

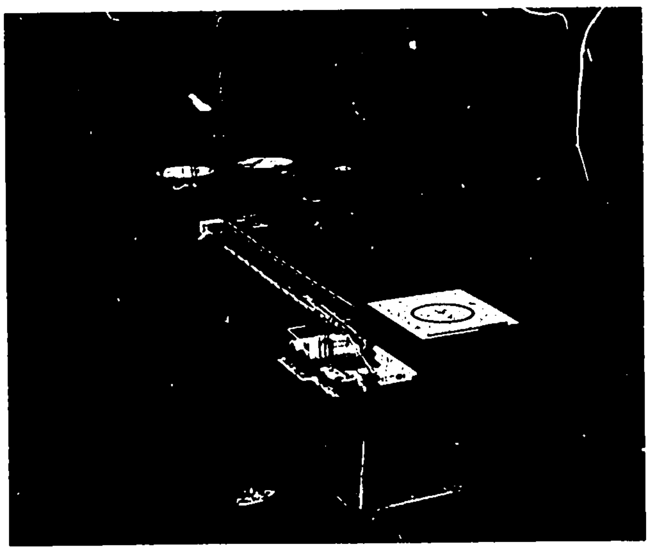


Fig. 46-3. This is an offshore drilling rig in operation.

Extracting Crude Oil

The petroleum industry has special problems in *extracting* raw materials. Coal, air, water, clay, sand, and ores (raw materials for primary metals and the chemical industries) are found on or near the surface of the earth. Crude oil may be found as far as four miles beneath the surface. Wells are located on land, Fig. 46-2, or they are drilled in offshore locations, Fig. 46-3.

Geologists are employed to *prospect* (look) for petroleum. Once petroleum has been found, the land is leased. Then a well is drilled, Figs. 46-4 and 46-5. A well drilled on

Fig. 46-4. A driller guides the drill bit into the hole.

Fig. 46-2. Here a crew is looking for oil on land.

Fig. 46-5. As a well gets deeper, new sections are added to the pipe that turns the drill bit.

land where oil is not now being produced is called a *wildcat well.* If oil or gas is found in large enough quantities, it becomes a *producing well.* If it produces no oil or gas, it is called a *dry hole.*

When a well gets to an oil or gas *pool,* the petroleum engineer extracts it in the best way. If the underground pressure is not high enough, pumps are used to draw or force the petroleum up the well.

The petroleum comes up to the surface in a foamy mixture of oil and gas. Then the natural gas is separated from the crude oil. The crude oil is sent to storage or to a refinery. The natural gas is sold as fuel or as raw material to petrochemical plants.

Transporting Crude Oil

Crude oil is a liquid. Thus it can be moved easily in several different ways. Pumping crude oil through pipelines is the main way of getting it from the well to the refinery, Figs. 46-6 and 46-7. Crude oil may also be transported to the refinery in large ocean tankers, barges, railroad tank cars, or tank trucks.

Refining Crude Oil

Crude oil cannot be used in the form it comes from the earth. It must be put through improving and changing processes. These are called *refining* processes in the petroleum industry. The molecules of crude oil have different numbers of hydrogen and carbon atoms set up in many different patterns. Those molecules with many carbon atoms make up the thicker forms of petroleum like asphalt. Those with fewer carbon atoms make up the thinner forms like gasoline.

The molecules of crude oil can be separated according to their size and weight. This is done by a special kind of *distilling.* This process separates the crude oil into *fractions:* gases, gasoline, kerosene, and oils of different weight. The fractions of crude oil have different boiling points. They can be separated by heating the crude oil until it becomes a vapor. Then it is cooled. Each fraction becomes a liquid at a different temperature. This is done in a "fractionating" tower. The different fractions are then drawn off from the tower at different levels. They leave the tower separately for further processing somewhere else.

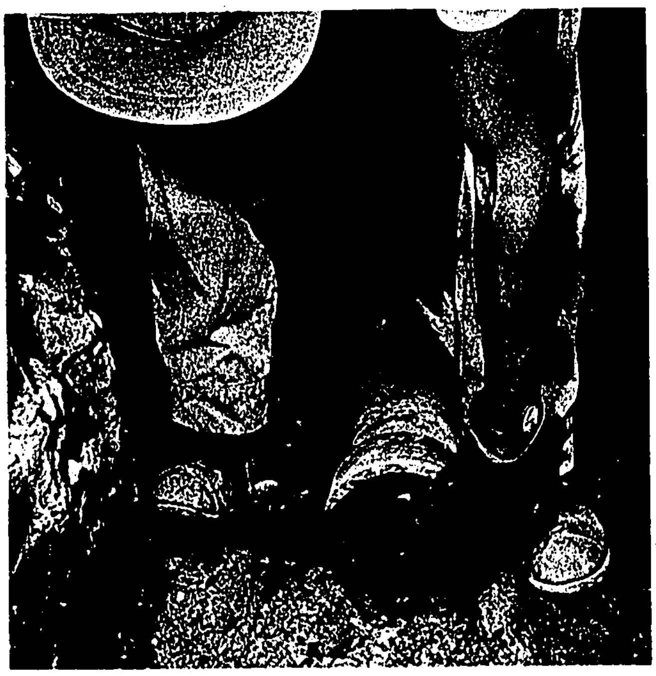


Fig. 46-6. Pipe must be laid to transport the crude oil.

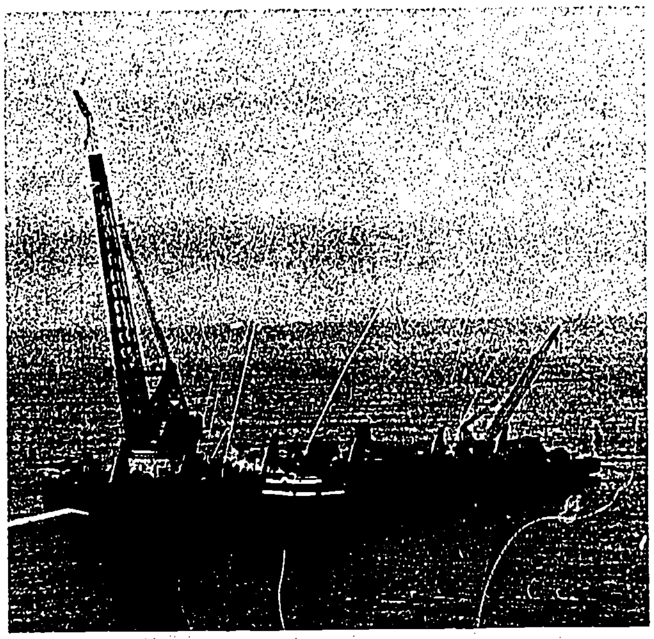


Fig. 46-7. This barge is laying pipe which will carry oil from the offshore well to a storage site.

Crude oil usually has some fractions, such as gasoline, in small quantities. These are too small to meet the needs of customers, so a process called *cracking* is used to get larger amounts of the thinner fractions from the thicker fractions. *Thermal cracking* uses heat and pressure to break larger molecules into smaller ones. Cracking often uses a *catalyst* which speeds up the breakdown of the larger molecules. Cracking helps the refiner get much more gasoline from each barrel of crude oil. It also helps to form many new compounds.

There is a process in which a number of small molecules are joined to form a single large molecule. It is the reverse of cracking and is called *polymerization.* Cracking and polymerization are two of the most important processes used to make many different petroleum products.

Research and Development

Research and development of new products are important to the petroleum industry. Petroleum is a very useful raw material. Much research is done to develop new compounds that will have many possible uses. Researchers have developed many new products which either improved or replaced products on the market. They have also developed many which could only be gotten from other raw materials.

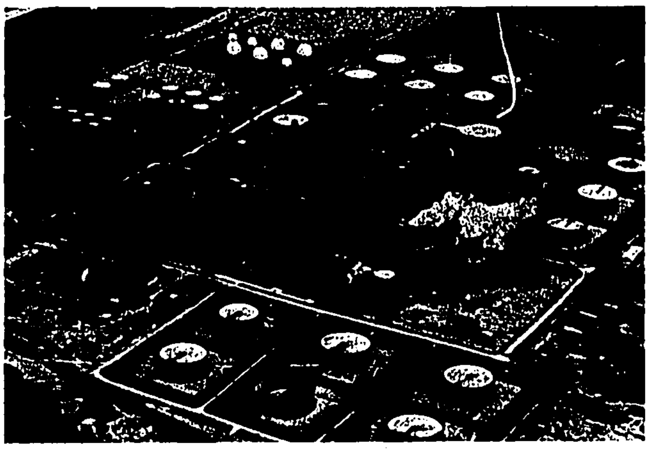


Fig. 46-8. This refinery's storage site has 45 tanks.

Process Engineering

The United States produces over four billion barrels of crude oil each year, Fig. 46-8. This is possible only because new ways have been developed to get the oil from the rock and sand and to bring it to the surface. As much as 50 percent of the oil can be gotten from pools that would give up only 10 percent or less if they were allowed to flow naturally. Many old or deserted oil fields have been reopened with these new methods.

Suppose a new, useful product has been developed in the laboratory. Then a manufacturing system must be designed to produce it. This includes the design and construction of plants, production machinery and equipment, and moving (*transporting*) and shipping (*distributing*) systems. After a production system has been set up, changes and improvements are always needed in order to improve efficiency and the quality of the product. The use of the quality control methods and automated machinery are very important.

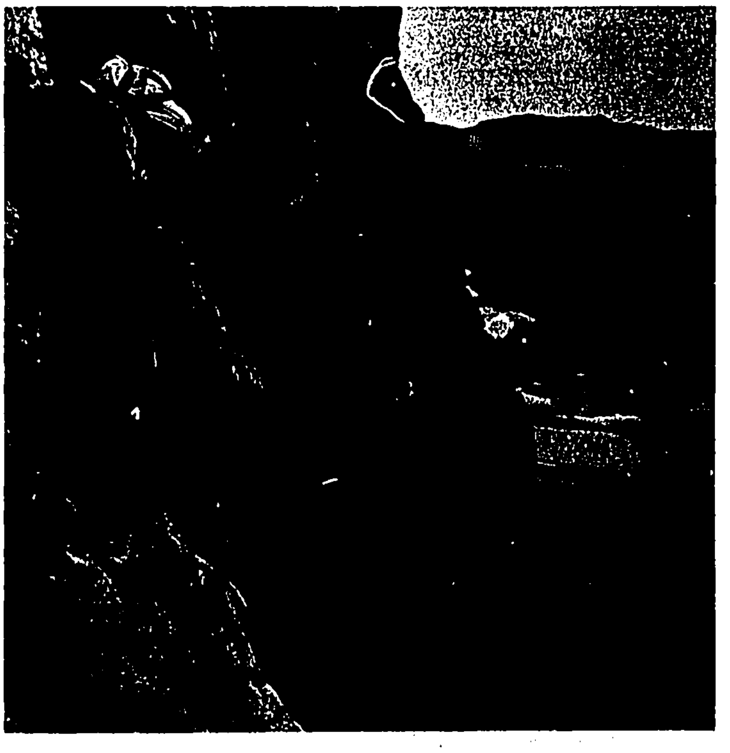


Fig. 46-9. This geologist is collecting samples of the earth.

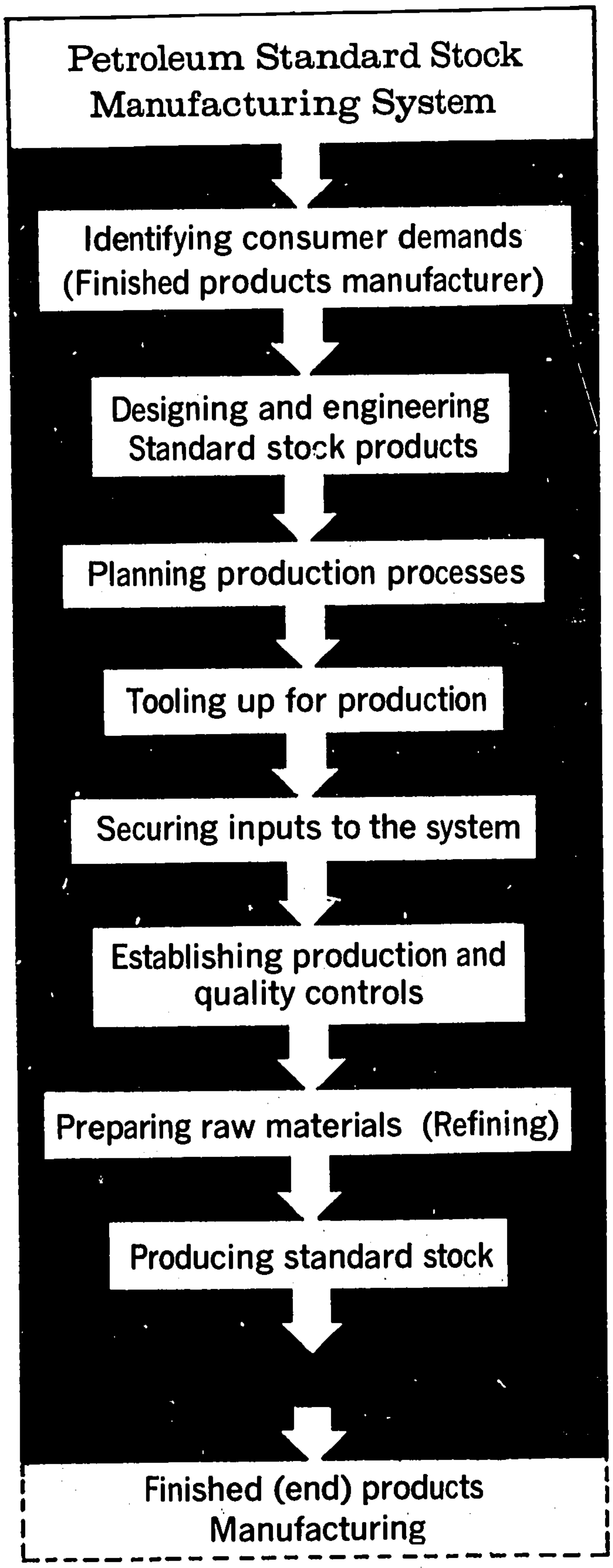
Careers in the Petroleum Industry

There are almost as many jobs in the petroleum industry as there are products made from oil or gas. People are needed to find, extract, transport, and refine petroleum. People are also needed to make and sell the finished products. Geologists, paleontologists, geophysicists, surveyors, and others are needed to look for petroleum, Fig. 46-9. Drillers and petroleum engineers help extract the petroleum, Fig. 46-10. Pipeline workers, pumpers, seamen, truck drivers, and others transport the crude oil to the refinery. Refinery workers, chemists, physicists, engineers, and technicians refine and change the crude oil into materials that can be used. People skilled in all phases of industry are needed to make and sell the many petroleum products.

Summary

Petroleum is a raw material for an almost endless number of products. Partly decayed organic material is the source of petroleum. It is found in collections inside the rocks of the earth's crust. The geologist looks for petroleum. Then it is extracted by drilling. After extraction, petroleum is sent to a refinery, usually through pipelines. Refining petroleum means breaking down and recombining its fractions to make new and different products. Many kinds of fuel, waxes, lubricants, solvents, and petrochemicals come from petroleum. Petrochemicals are important in making plastics, synthetic rubber, insecticides, detergents, synthetic fibers, explosives, and many other products. Research and development in the petroleum industry have led to finding widespread uses for petroleum and its products. Many people are needed to find, extract, transport, and refine petroleum. An equally large number of people are needed to make and sell petroleum products.

Fig. 46-10. It takes many skilled and strong men to operate a drilling rig.



Terms to Know

petroleum
gas
liquid
semisolid
crude oil
natural gas
asphalt
pitch
viscosity
sediment
porous
molecules
petrochemicals
extracting
prospect
wildcat well
producing well
dry hole
pool
refining
distilling
fractions
cracking
thermal cracking
catalyst
polymerization
transporting
distributing
nonreproducible

Think About It!

1. Why is petroleum a *nonreproducible* mineral resource?
2. What kinds of *petroleum* products are used in your home? How many of them are *petrochemical* products?

READING 47

Story of Chemical Products

You have learned about primary metal, textile, and petroleum products. In this reading you will learn about *chemical* products which are important to these and many other industries. Most chemical companies *refine* (improve) and *convert* (change) raw materials to products that can be used. Most of their products become "raw" materials for other industries.

Chemical Raw Materials

Chemicals are gotten from two kinds of natural sources, called *organic* and *inorganic.* The organic sources come from living or once living plants and animals. These sources include farms and forests, coal, petroleum, and natural gas. The inorganic (nonliving) sources include sand, metal ores, water, air, and many other minerals. The chemical industry depends a great deal on about ten source chemicals. These include both organic and inorganic kinds. They are oxygen and nitrogen from the air, water, sulphur, salt, clay, limestone, potash, coal, and petroleum, Fig. 47-1. These are the real "workhorses" of the chemical industry.

How Industry Uses Chemical Products

Almost everything we use in our daily lives has chemical products in it or has used some while it was being made. A large group of chemical products are used in manufacturing as *process chemicals.* They do not become part of any end-product. There are *acids* used for cleaning metals. There are *solvents* used in the printing, textile, and

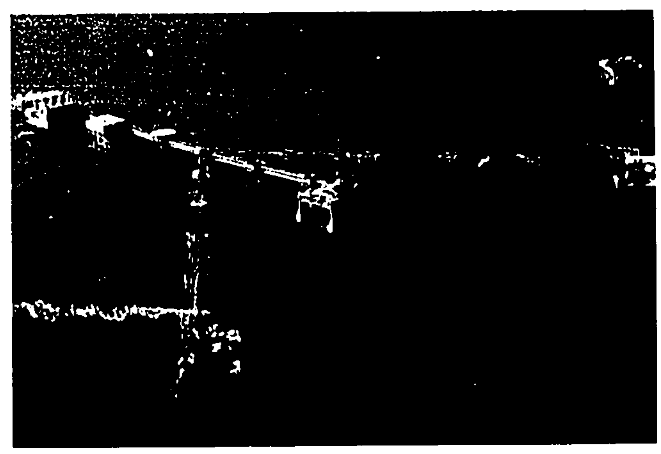


Fig. 47-1. This is an offshore sulphur mine. Sulphur is a basic material used by the chemical industries.

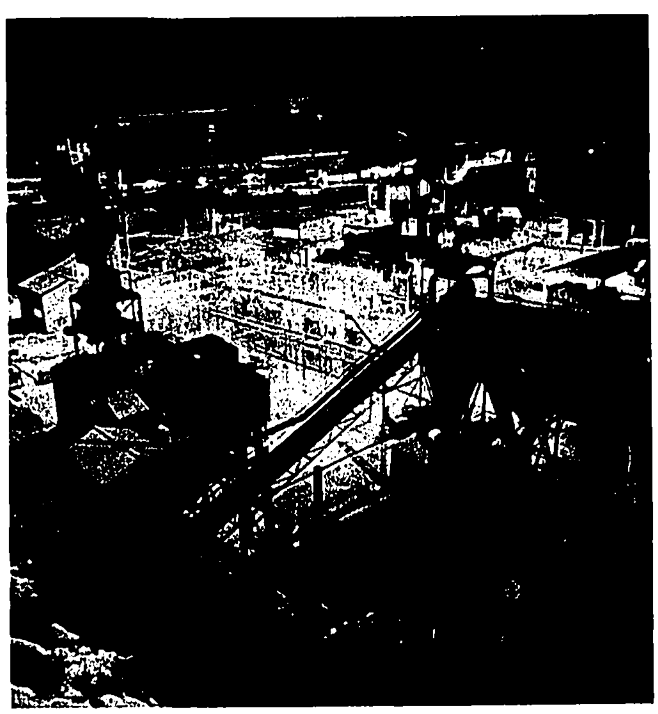


Fig. 47-2. This chemical processing plant takes raw materials from the earth. Then it processes them into basic chemical products used by other chemical industries.

plastics industries. There are ammonias, alcohols, and *catalysts* (materials that speed up chemical reactions) of many kinds.

A second group of chemical products are used as "raw" materials by other industries. They *do* become part of the end-product, Fig. 47-2. These chemicals include plastic resins, paint components, synthetic rubber compounds, vitamins, food preservatives and other food additives, dyes, and pigments.

A third group of chemical products are used in the form they are made, by industry and the public. These chemicals include fuels, lubricants, drugs, inks, fertilizers, and detergents.

Chemical Processing

Chemicals are produced by changing raw materials so that the end-products are more useful than the raw materials were. Changing raw materials is done by (1) refining them, and (2) changing their chemical form.

Refining Raw Materials

We get most of our raw materials from the earth, Fig. 47-3. These materials are found in the natural state as *solids, liquids,* or *gases*. Most raw materials from the earth must be improved (refined). Both physical and chemical means are used in *refining* (improving).

The usual physical methods of refining raw materials are (1) *washing*, (2) *grinding*, (3) *screening*, (4) *filtering*, and (5) *floating*. Washing means taking dirt off the material and flushing with a liquid. Passing the materials through a screen is done to get pieces of the same size. Screening is often combined with grinding. Grinding reduces the size of pieces. Filtering of a liquid takes out solids not wanted. It can also be used to separate solid materials from liquids, Fig. 47-4. Floating methods are used to separate solids of different qualities. Certain substances called *surface-active agents* can cause water to foam when air is put in. The foam will hold lightweight solids. These solids can then be taken off with the foam. These solids are used in some other process, or they are thrown away.

Chemical methods of refining raw materials usually cost more than physical methods, so they are used less often. An example of chemical refining is separating pulp from wood. Chemicals are added to the wood so the *lignin* in the wood will dissolve.

Fig. 47-3. Coal is a raw material of the chemical industries. Here coal is being moved from a mine on a conveyer belt.

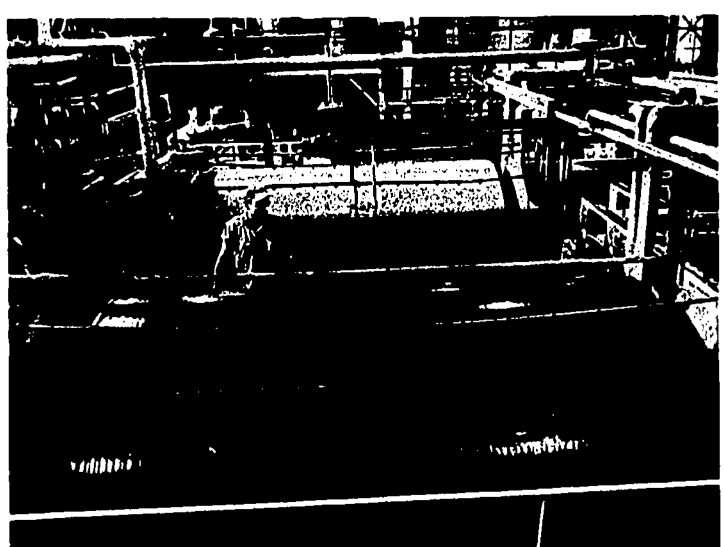


Fig. 47-4. Filtering is part of the fermentation process in making a chemical product.

Then the liquid which holds the dissolved lignin is taken off. The *cellulose* portion of the wood is left as a solid to be further processed.

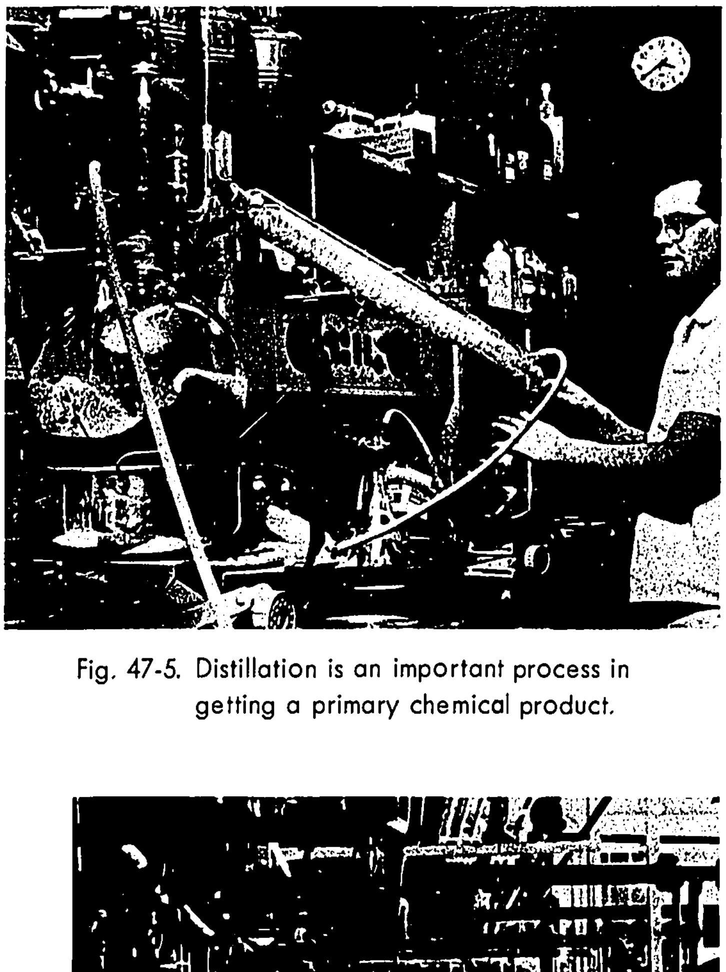


Fig. 47-5. Distillation is an important process in getting a primary chemical product.

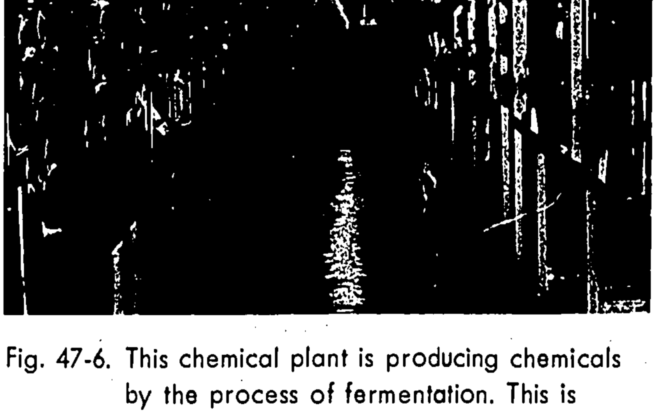


Fig. 47-6. This chemical plant is producing chemicals by the process of fermentation. This is a chemical change caused by the action of micro-organisms.

Chemical Transformations

A large number of *transforming* (form changing) operations are used to make chemical changes. Five important ones are: (1) *oxidation*, (2) *electrolysis*, (3) *distillation*, (4) *fermentation*, and (5) *polymerization*.

Oxidation is used mainly in the organic chemical industry. Oxidation means putting oxygen into an organic *molecule* (combination of atoms). Oxidation produces heat.

Electrolysis is the use of direct current electricity in a melted solid or a liquid to *decompose* (break down) a chemical. The products can be solids, liquids, or gases. Several products are usually produced at the same time in electrolysis. Aluminum, magnesium, chlorine, and caustic soda are some of the products made by electrolysis.

Distillation means *vaporizing* a liquid (changing to steam or gas). This is done to separate it from another liquid or from a solid which was dissolved in it, Fig. 47-5. The vapor can be *recondensed* (returned to liquid) in a nearly pure state. Seawater is distilled to separate pure water from salts. Products like gasoline and kerosene are separated from crude oil by distilling.

Fermentation is a chemical change caused by the action of *microorganisms* (bacteria and yeasts), Fig. 47-6. In the world of nature fermentation is very important. Fermentation is used to produce many products for which there is a great need, such as synthetic vitamins.

Polymerization is a chemical process in which small molecules are joined to form large molecules. It is very important since nearly all plastic products are formed by polymerization.

Research and Development

Man has always used natural resources as chemicals. Until about a hundred years ago, most chemicals were gotten by refining raw materials without any chemical *transformations* (changes). More recently, chemical

transformations have become more important. Chemical products that are produced this way are often called *synthetic materials.* The modern *plastics* industry depends almost entirely on synthetic chemicals.

New developments have come from inside the chemical industry and from other industries. Most plastics were known to chemists many years before there was a great need for them. On the other hand, synthetic rubber was developed to meet the shortage of natural rubber during World War II. Chemical production, more than any other large industry, depends on research.

Most new chemicals are first produced in small amounts in a laboratory, Fig. 47-7. Much designing and engineering is needed to produce chemicals cheaply in large amounts. This is done by chemical engineers, physicists, electrical engineers, mechanical engineers, civil engineers, and industrial engineers.

Chemical plant design presents many problems. A process which worked in a laboratory may not work the same way when it is tried in a factory. Many chemicals are very *corrosive* (eat away the surfaces of other materials). The pumps, pipes, and tanks that hold these chemicals must not corrode, Fig. 47-8. The cost of these special containers may be hard to know before the plant is in actual operation. Many of these problems may be solved by first building and running a small plant, called a *pilot plant.*

Fig. 47-7. A chemist in a chemical laboratory is testing a new compound formula.

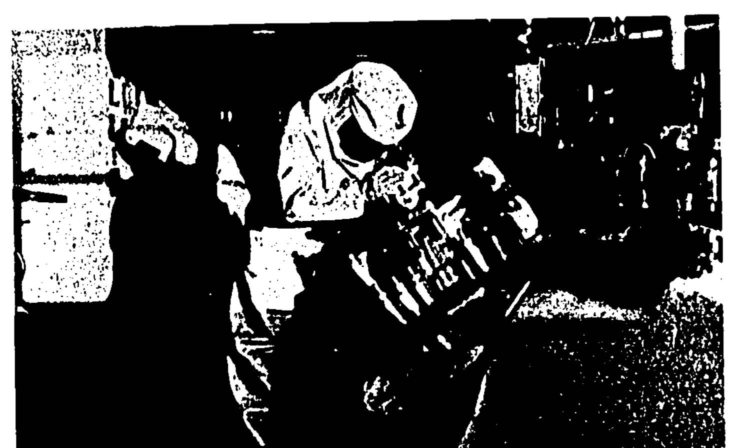


Fig. 47-8. Chemical plants must have pipes, pumps, and tanks that will not corrode.

Controlling Production

Many chemical products are used as drugs and in food products. Quality control, then, is very important. Many chemical compounds are *unstable* (tend to change their makeup by themselves), so they must be carefully controlled. Quality usually is controlled by inspecting the product often to correctly measure its makeup. This kind of work is done by an *analytical chemist,* Fig. 47-9.

Many of the ideas of *automation* (automatic control) were developed in the chemi-

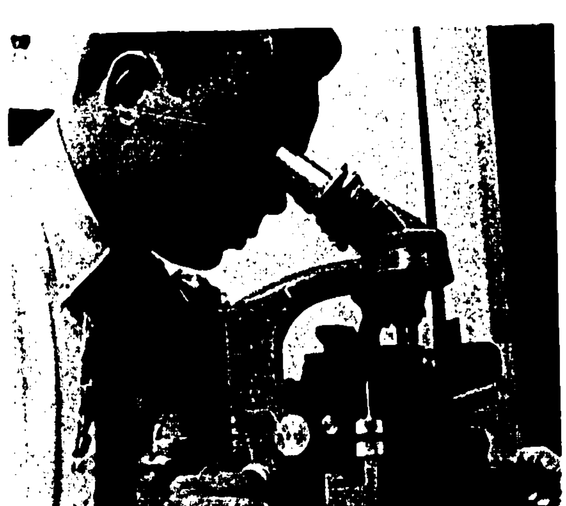


Fig. 47-9. This analytical chemist is hard at work.

cal industries, Fig. 47-10. Controls can be run automatically so that only a few workers are needed to man a whole plant. A computer may even replace these few workers. Many newer chemical plants need only *maintenance* (upkeep) men for operation.

Fig. 47-10. This chemical plant has been automated to increase efficiency.

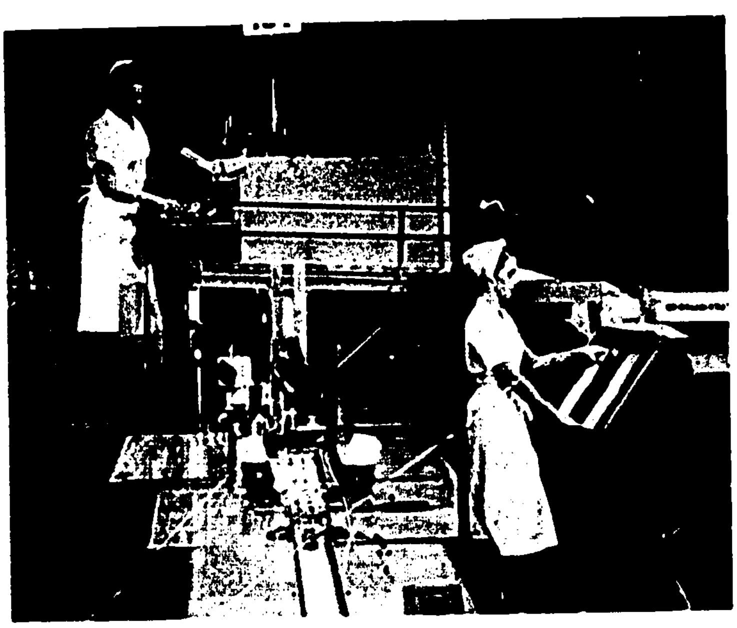


Fig. 47-11. These women are workers on a production line in a chemical plant.

Personnel

There are many kinds of jobs in the chemical industry. There are three kinds of production and service workers. First, there are unskilled workers who move materials, load boxcars, handle shipments, clean and wash equipment, and lubricate production process equipment. Second, there are semiskilled workers like quality inspectors, stockroom clerks, equipment operators, and maintenance men, Fig. 47-11. Third, there are skilled technicians whose work is not an engineer's job, but is still above a semiskilled worker's job, Figs. 47-12 and 47-13. Technicians work in the chemical, metallurgical, electrical, design, mechanical, and instrumentation areas. The use of automation has opened up many jobs in data processing.

Many jobs are open to people with special training and education. The chemical industry needs civil, chemical, electrical, mechanical, and industrial engineers to operate its plants well. Chemists are also needed for research programs, Fig. 47-14.

Fig. 47-12. The tensile strength of a chemical product is being tested by a technician.

Fig. 47-13. This technician is studying the properties of a chemical.

Summary

Chemicals are part of each person's daily life. They are basic to many industries. Most natural materials may be used as raw materials to make chemical products. Research has developed synthetic materials from natural materials.

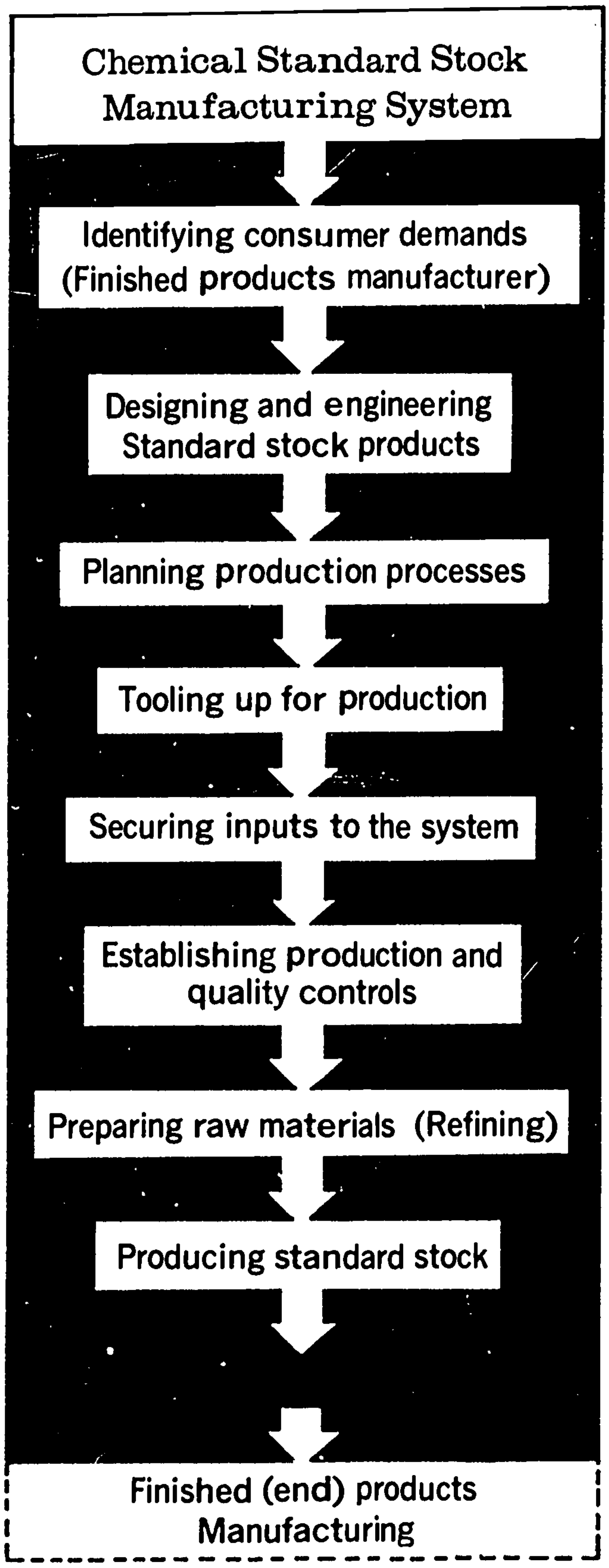
There are many refining and transforming methods used by the chemical industry. The main refining processes are washing, grinding, screening, filtering, and floating. These are physical processes. The main transforming processes include oxidation, electrolysis, distillation, fermentation, and polymerization. These processes bring about chemical changes.

The chemical industry affects most other kinds of manufacturing activity. Without the products of the chemical industry, our life would be very different today.

Fig. 47-14. A chemical engineer is analyzing a chemical product.

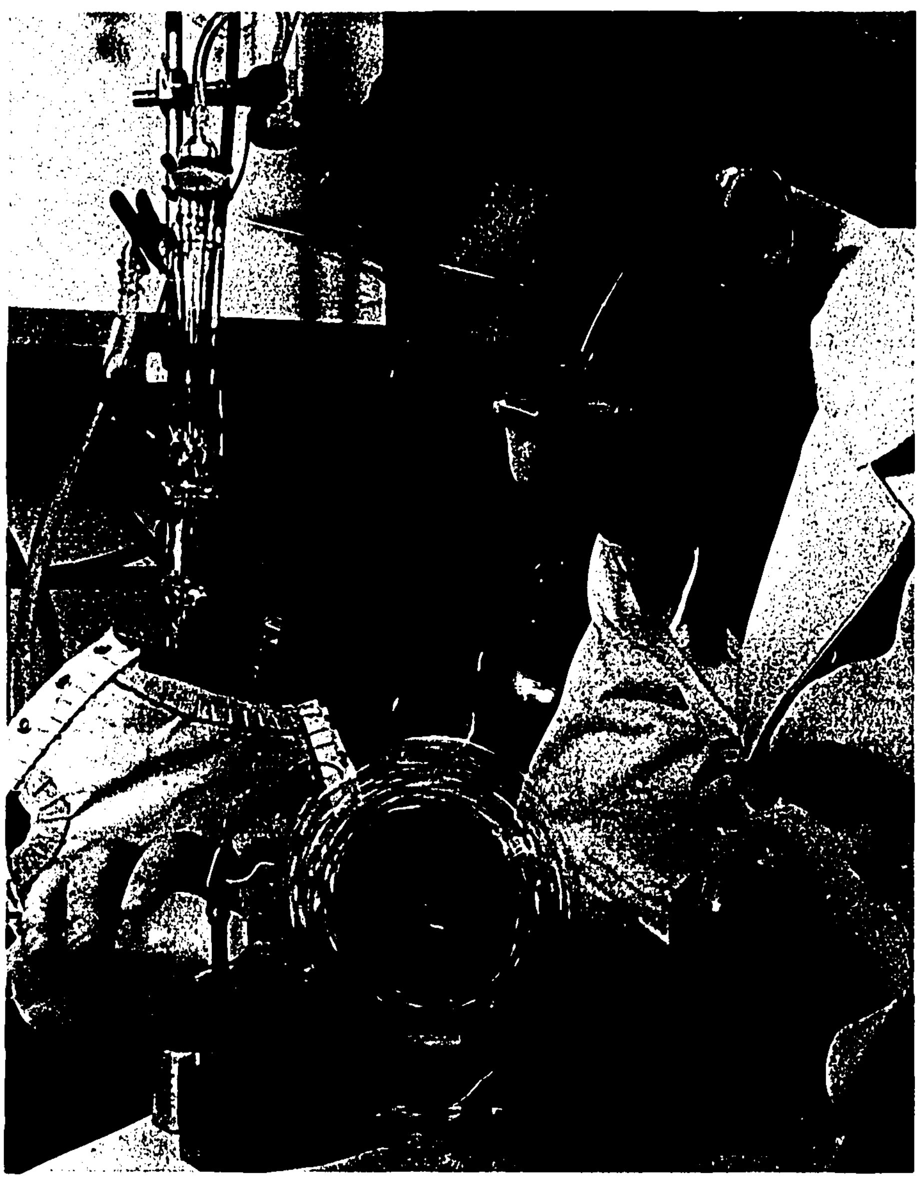
Terms to Know

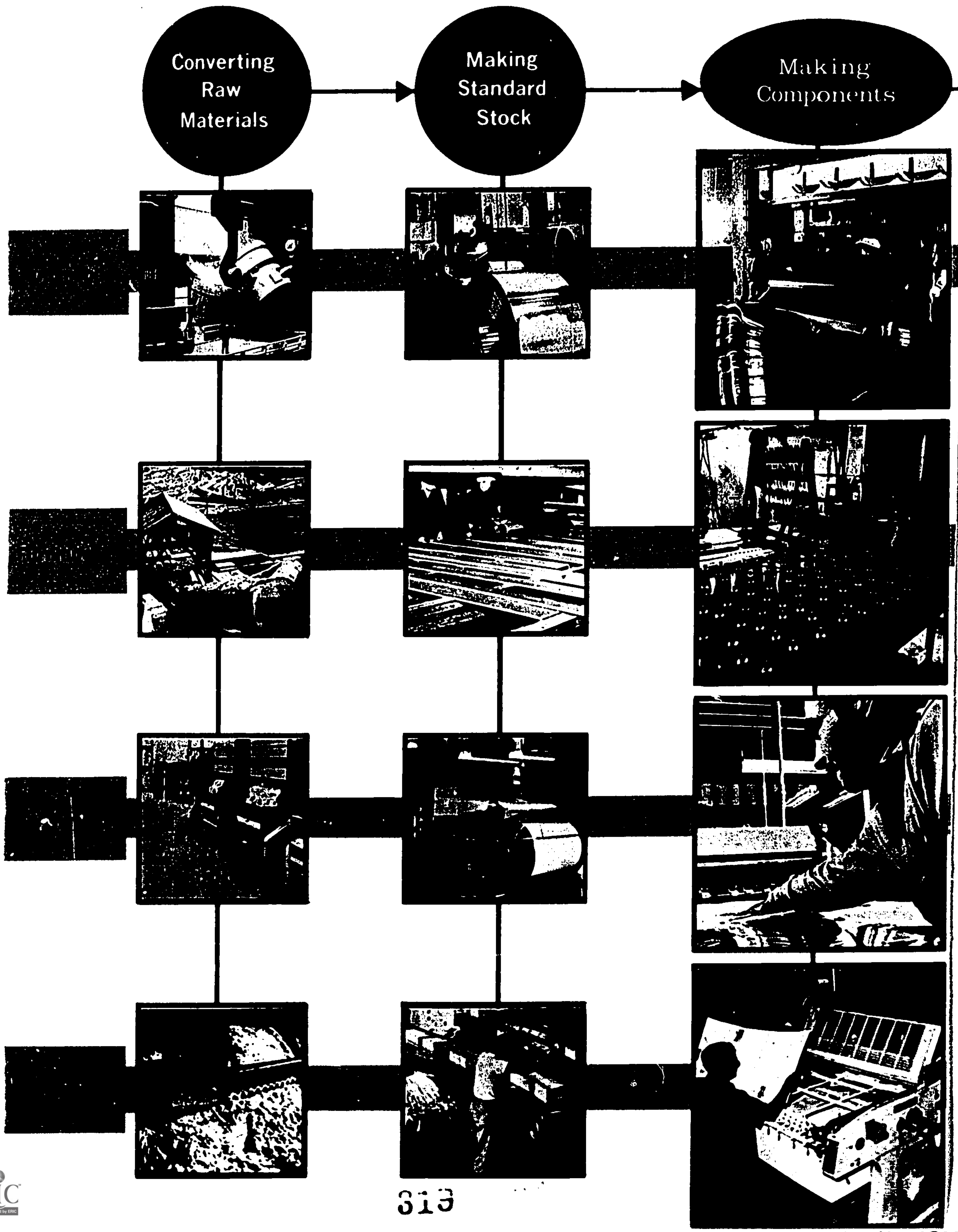
chemical
refine
convert
organic
inorganic
process chemicals
acids
solvents
catalysts
solids
liquids
gases
refined
refining
  a. washing
  b. grinding
  c. screening
  d. filtering
  e. floating
surface-active agents
lignin
cellulose
transforming
  a. oxidation
  b. electrolysis
  c. distillation
  d. fermentation
  e. polymerization
molecule
decompose
vaporizing
recondensed
microorganisms
transformations
synthetic materials
plastics
corrosive
pilot plant
unstable
analytical chemist
automation
maintenance
chemical products

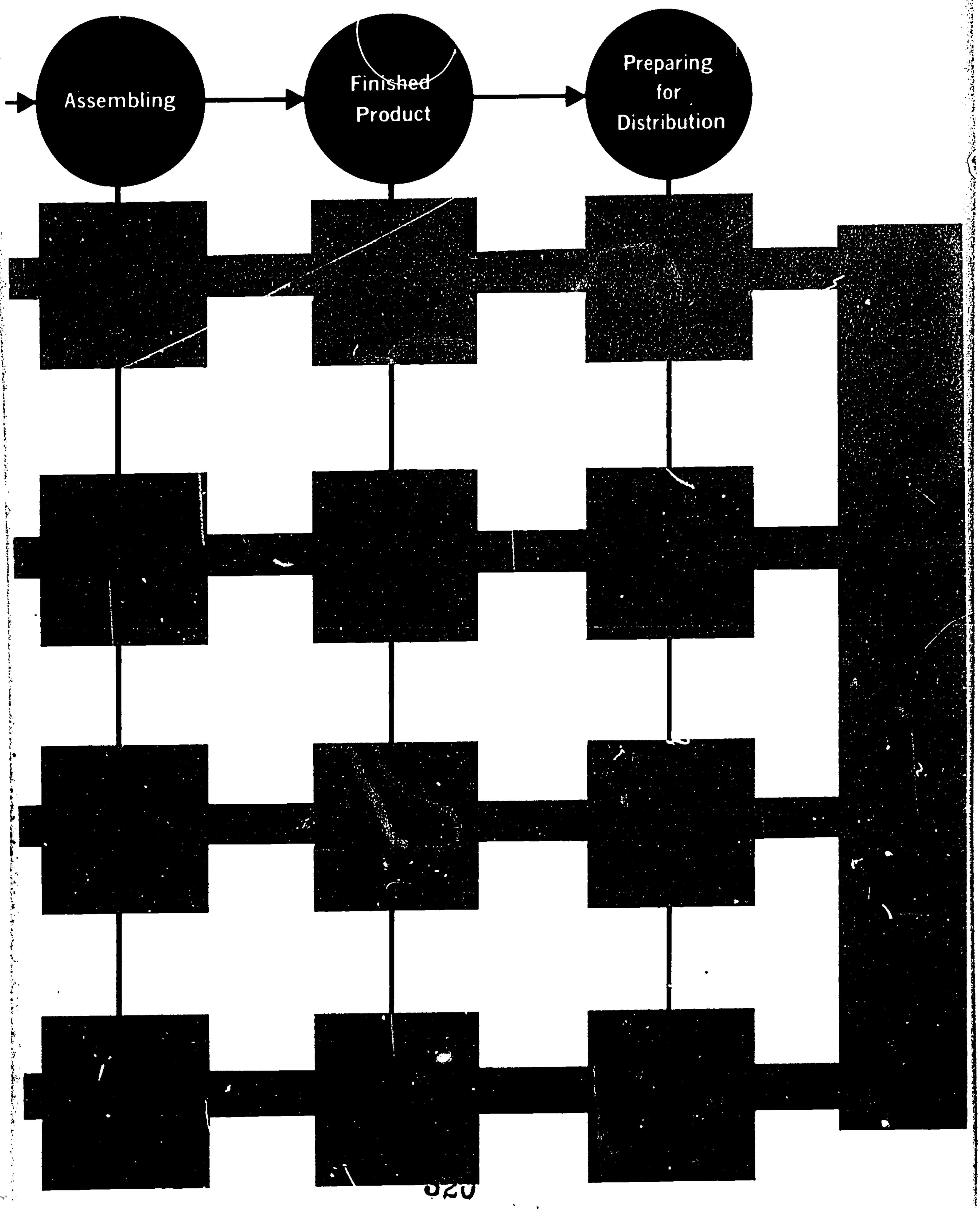


Think About It!

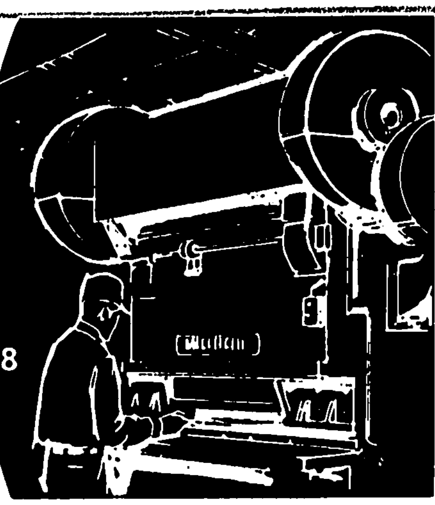
1. Why do you think the *chemical* industry has depended more on research and development than other large industries?
2. What kinds of *chemical products* are used in your home? How many of them are *process* chemicals?




Converting Raw Materials
Making Standard Stock
Making Components


Assembling
Finished Product
Preparing for Distribution

READING 48



Making Components by Forming or Separating Standard Stock

You have learned how some factories or plants make only *standard stock.* These plants are part of the *primary industries.* Prior to this reading, you learned about four of them. They were: (1) primary metals, (2) textile mill products, (3) petroleum, and (4) chemical products.

Many secondary plants use standard stock from the primary industries as their "raw material" and *process* (change) it further, Fig. 48-1. Some stock is changed into simple one-piece finished products. For instance, wire stock may be cut and bent into paper clips. Some stock is changed into *components* (parts to be combined with other parts), Fig. 48-2. These parts can later be *assembled* (put together) to make finished products. For instance, the coil of wire that holds the sheets of a spiral notebook together is a component. It is combined with the pages and cover to make a complete product. There are two basic ways to change standard stock into one-piece products or into parts. These are *forming* and *separating.*

After parts are made, they are often combined with other parts to make more *complex* (complicated) products. In later readings, you will learn more about *combining* (assembling).

Changing Form

The word *form* is most often used to mean shape. Form can also refer to other *properties* (features). A material can be *dense* (solid), *resilient* (able to spring back into shape), *rigid* (firm), *viscous* (thick), strong, or hard. It can have color, texture, odor, size, or *internal* (inside) structure.

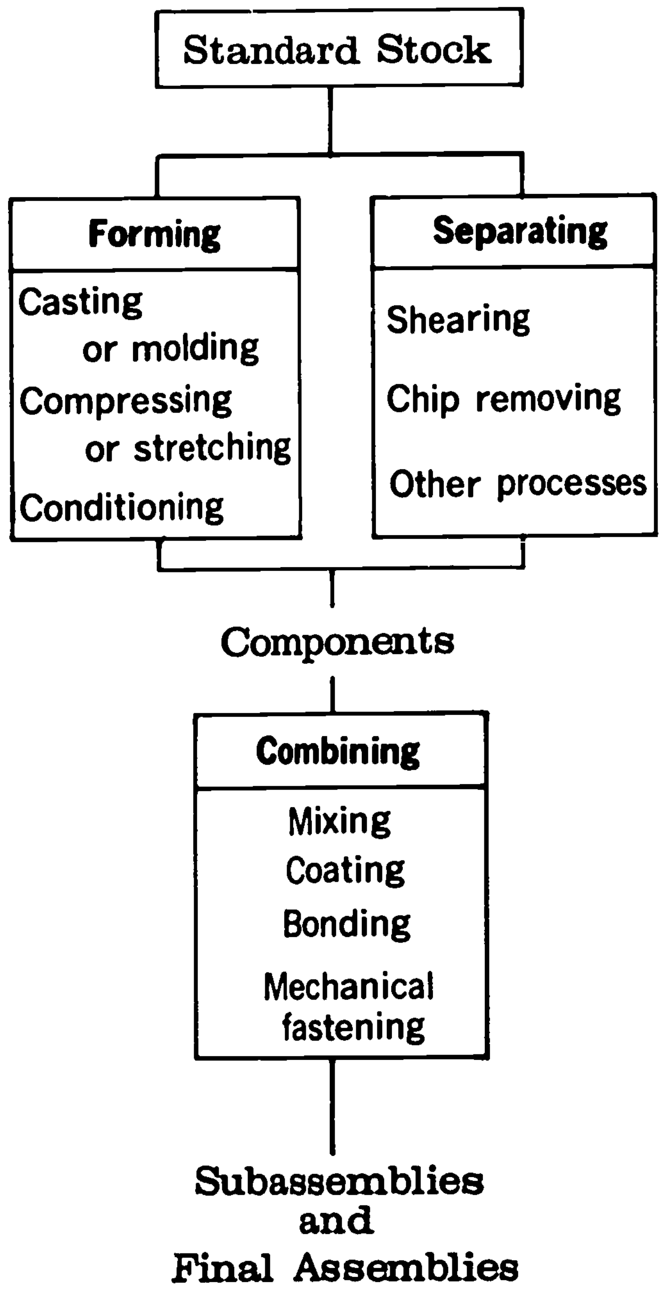


Fig. 48-1. Components are made by forming and separating practices.

When the form of materials is changed, shape is the feature that is most often changed. In fact, most processes are done in order to get the right material into the right shape.

As you learned in one of the earlier readings, one of the *primary* (first) changes in form takes place when standard stock is made. In this form, material cannot be made into final shapes like bolts, shoes, dishes, books, or oven doors. Sometimes only one more change of form is needed, as was the case of the paper clip. Most products go through a series of form changes.

Standard stock usually comes in sizes and shapes that make further forming easy. Sometimes the physical form of the standard stock is changed by the process used. This is true when metal *pigs* are melted and the liquid metal is poured into molds, Fig. 48-3. Sometimes the shape of the standard stock is not changed very much at all. This is true of rolled metals like structural steel stock. It is usually cut into different lengths. It can also have holes drilled or punched into it for rivets. See Fig. 48-4.

Standard stock chemicals come in many forms. Much of the chemical standard stock

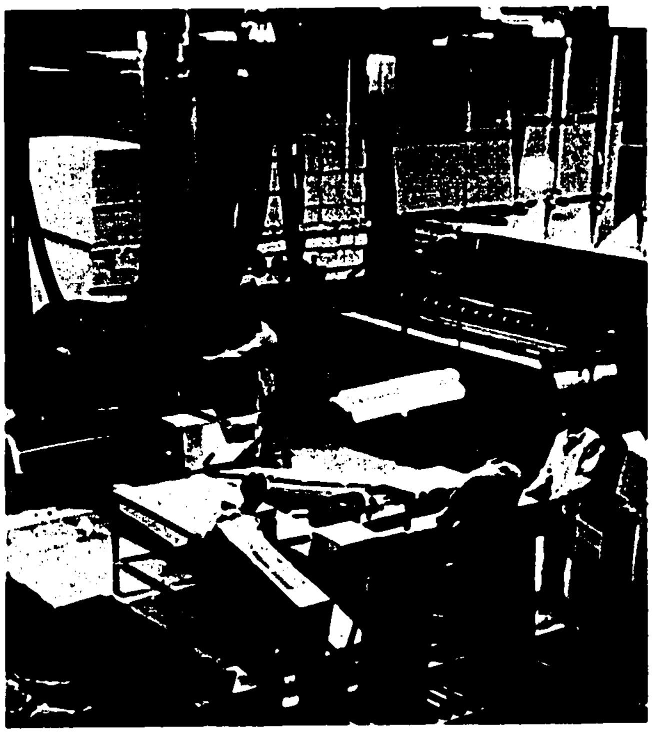


Fig. 48-2. Manufacturing plants usually make parts or finished products from standard stock. These workers are making and packing ceiling tiles from large standard-size sheets of insulating board.

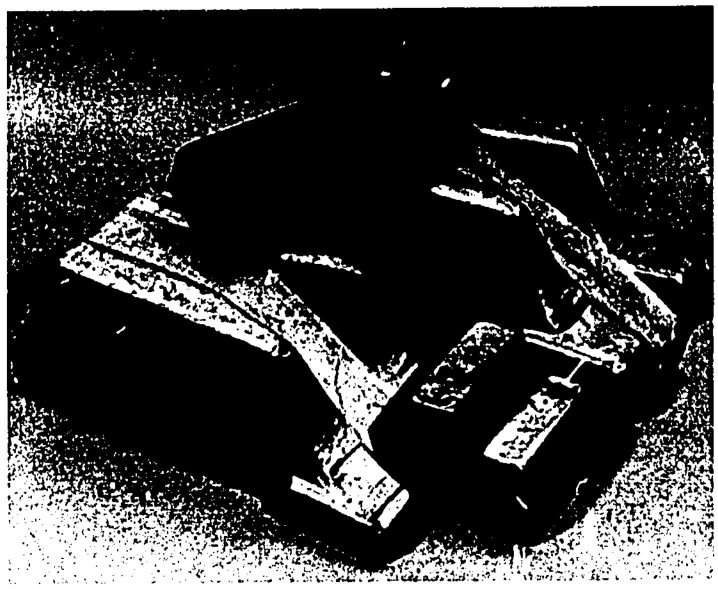


Fig. 48-3. The physical form of the standard stock is changed when pigs or ingots are melted and poured into molds.

Fig. 48-4. Some parts are made by only slightly changing the form of the standard stock. This structural steel stock is cut to length and has holes punched in it.

comes in the form of liquids and powders. These liquids and powders are further processed and combined into products such as medicines, cleaning agents, lubricants, and paints.

Forming and Separating

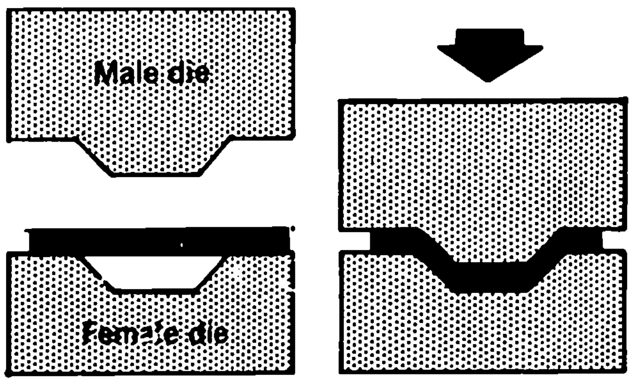
There are two different ways to make a part or a one-piece product from standard stock. First, the internal or *external* (outside) features may be changed by *forming*. Forming does not add or *remove* (take away) any material. Second, if there is any *excess* material (more than is needed), some of it can be taken off by *separating*. This will leave the right amount of stock in the right shape.

Forming Practices

Forming is often the best way to change standard stock into another shape. It is the best way because there is seldom any material wasted. Forming is sometimes best only for large numbers of certain products because of the high cost of tooling-up. This cost is high because the tools that do the forming are often specially made for each product and can only be used for that one product.

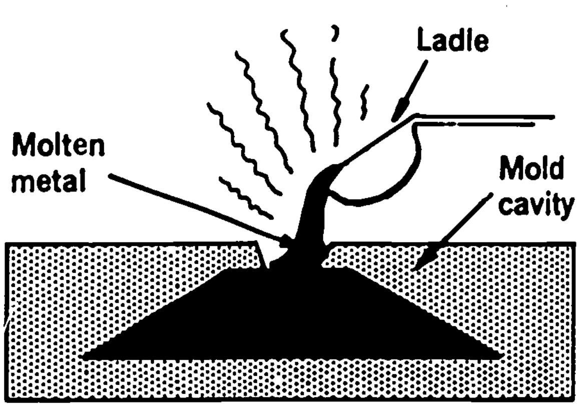
There are three basic ways of forming. They are (1) *casting* or *molding*, (2) *compressing* or *stretching*, and (3) *material conditioning*.

In *casting* or *molding*, standard stock in liquid or semiliquid form is poured or forced into a *cavity* (hollow space) of the right shape and then allowed to harden, Fig. 48-5.



Forming by Compressing or Stretching

Fig. 48-6. In compressing or stretching, standard stock in a plastic or solid form may be given a new shape by forcing the stock against a tool or die.



Forming by Casting or Molding

Fig. 48-5. In casting or molding, liquid metal may be poured or forced into a cavity of the right shape and allowed to harden.

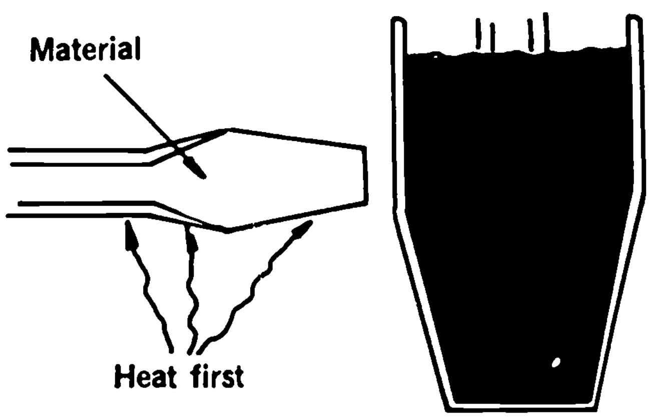


Fig. 48-7. In material conditioning, the external or internal structure of standard stock may be changed by the use of heat, chemicals, or electric current.

In *compressing* or *stretching*, standard stock in a *plastic* (soft) or solid form is forced into a new shape by *compressing* (squeezing) or *stretching* (pulling apart). See Fig. 48-6. Some of these processes are *forging, rolling, compression molding, bending, drawing,* and *press working* (stamping). Common materials that are compressed or stretched are: metals, plastics, and glasses in the form of sheets, rods, or tubes.

In *material conditioning*, the internal form or structure of the standard stock is changed by one of three major types of *conditioning*. They are:

1. *thermal conditioning* (heat treating),
2. *physical* or *mechanical deforming*, or
3. *chemical reactions*. See Fig. 48-7.

There are other ways of material conditioning that you will learn about in a later reading. Internal form changes often take place during other forming processes, Fig. 48-8.

Separating Practices

Forming may be the best way to change some shapes, but *separating* is more widely used. It is not easy to change the form of stone and *brittle* materials (those which break very easily). The form of wood cannot be changed very much. Most solid or rigid standard stock can be put into another shape if you start with a large piece of it and remove what is not needed.

To *separate* (remove what is not needed), workers often use a cutting tool that is harder and stronger than the standard stock being cut. There are three basic ways to separate standard stock. They are (1) *shearing*, (2) *chip removing*, and (3) *other processes*.

In shearing, standard stock may be *sheared* (cut) into two or more large parts, Fig. 48-9. For instance, paper can be sheared. In the chip-removing process, excess standard stock is removed in small *chips* (pieces) such as sawdust or metal chips, Fig. 48-10. In *other processes*, excess

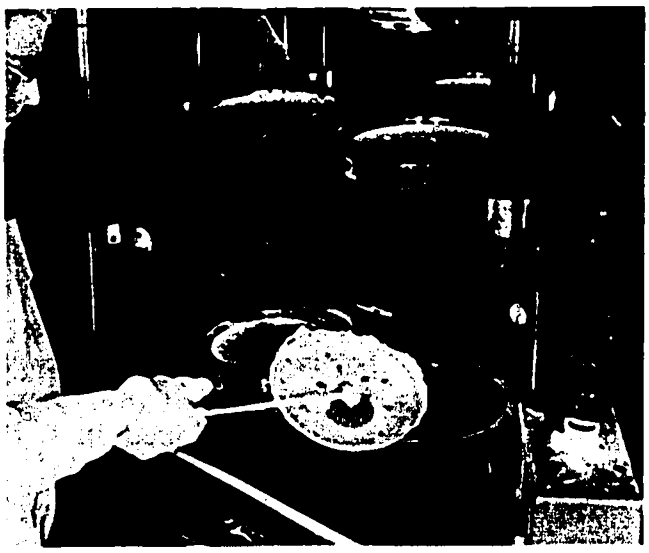
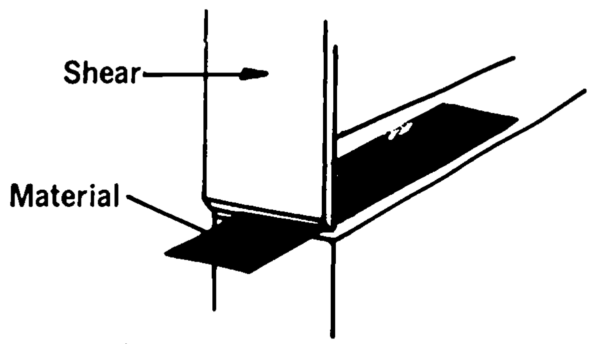
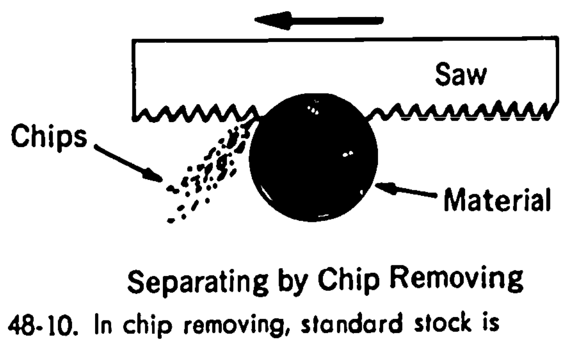


Fig. 48-8. This plastic dish was formed in a mold by heat and pressure. A suction cup is being used to lift the dish out of the opened mold.



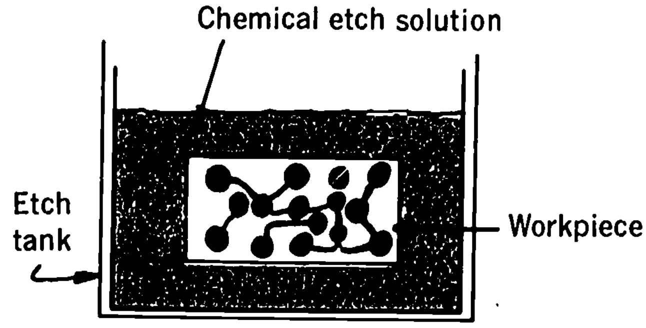
Separating by Shearing

Fig. 48-9. In shearing, standard stock is separated by a tool harder than the stock being cut. There is no material lost in the form of small chips.



Separating by Chip Removing

Fig. 48-10. In chip removing, standard stock is separated by cutting away small chips or pieces with a tool that is harder than the stock being cut.



Separating by Indirect Processes

Fig. 48-11. Separating by indirect means uses heat, chemicals, or electric current. Here a printed circuit for a radio is being etched by chemical means.

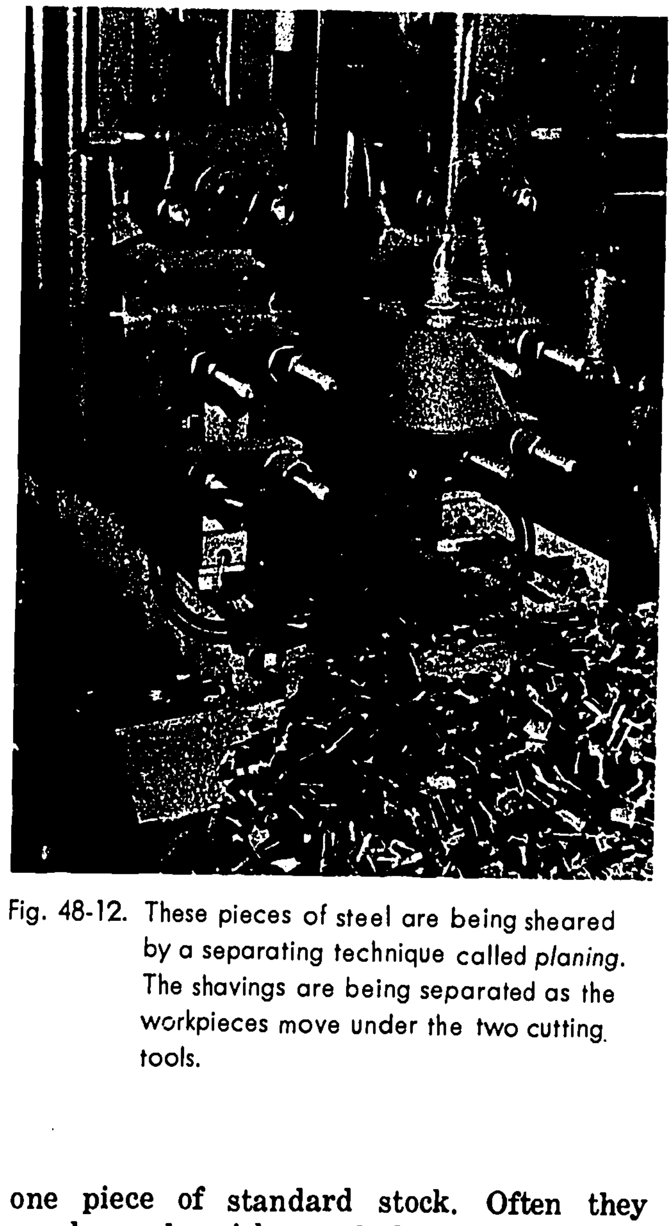


Fig. 48-12. These pieces of steel are being sheared by a separating technique called *planing*. The shavings are being separated as the workpieces move under the two cutting tools.

standard stock can be removed by indirect means such as heat, chemicals, or electric current, Fig. 48-11. Small chips may or may not result from these processes, Fig. 48-12.

The tools used to separate standard stock are often simpler than those used to form it, but production times are usually longer. Thus separating is often the best way to make small numbers of parts, while forming is the best way to make large numbers of the same parts. You can get better surfaces and closer *tolerances* (how much parts can differ in size and shape and still be used) by separating than you can by forming. Separating is often used to change the shape of parts that are first formed by casting or forging; for instance, cutting a thread in a hole cast in a car engine block.

Combining Components

Most products cannot be made from just one piece of standard stock. For instance, several *ingredients* (elements) must be *mixed* to make a loaf of bread or a can of paint. Most products are a combination of many parts put together. Even a simple pencil has five parts: the lead, two wooden halves, metal band, and eraser.

There are some parts and products that could be made by making many changes in one piece of standard stock. Often they can be made quicker and cheaper by joining two or more smaller pieces of stock. A car frame and a wooden chair are two good examples. Single pieces may be *bonded* (melted together) by welding, by soldering, or with *adhesives* (glues and cements). They may also be *mechanically fastened* with nails, bolts, screws, or staples. Some large machine parts are combined in both ways, Fig. 48-13.

There are some products made of single parts that move together, like hinges and wheels on axles. The movement is usually fixed by the shapes of the parts and by the kinds of mechanical fasteners used to hold them together.

The term *assembly* refers to the many ways in which parts are joined to make a product. The product itself may be called an assembly. Several parts can be joined to form a small unit of a product. This small unit is called a *subassembly*. For instance, a car door is a subassembly of the whole car.

Material Properties

The designer of a product often has a wide range of materials from which to choose. He wants a material to have features that will make it work in the product, Fig. 48-14. For instance, he may check a material for its strength, weight, *shock resistance* (not wearing out from heavy impacts), or *corrosion resistance* (not being eaten away by acids). For a part that the buyer will see, the designer will have to think about how it will look. He will not think as much about how the features of the material make the product easy or hard to make.

The features that make the manufacture of a product easy or hard depend on what processes will be used. For casting, the melting point is important. Standard stock that is to be formed by bending must be *ductile* (soft). This is true even if the product itself will not need to be ductile when it is used later. For shearing, standard stock should not be too soft or too hard. Cutting tools wear out too fast if the stock is harder than it should be.

If the product must be strong, process costs may be very high. When many different materials could be used, the material is selected because it costs less to buy or to process.

Summary

In manufacturing a product, there are several ways to change the form of standard stock materials. Standard stock can be made directly into one-piece products. It can also be made into parts. These parts are later combined to make more complex products.

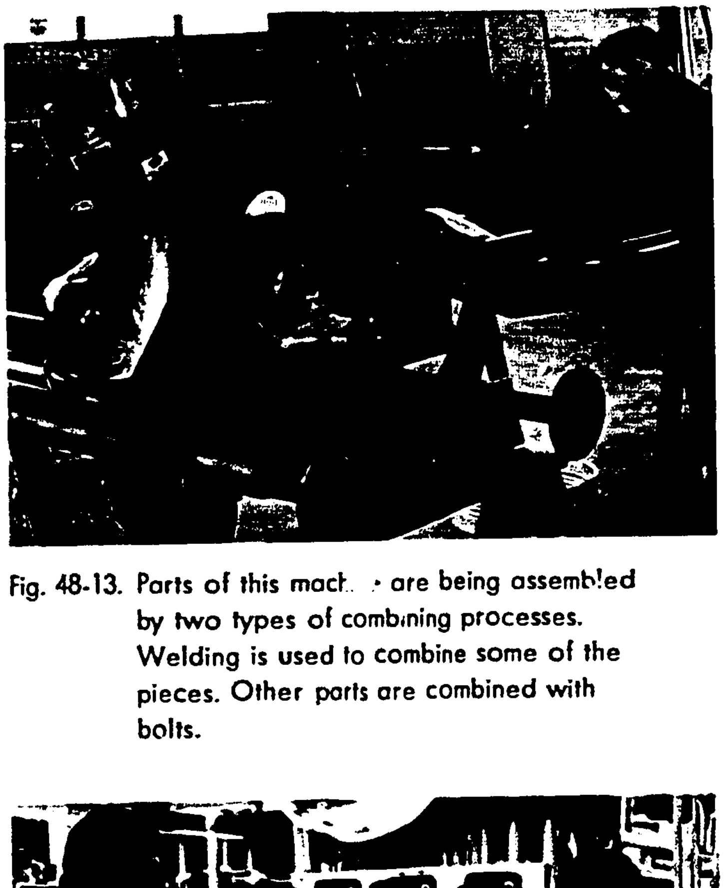


Fig. 48-13. Parts of this machine are being assembled by two types of combining processes. Welding is used to combine some of the pieces. Other parts are combined with bolts.

Fig. 48-14. These men are examining the features of the plastic sheet. They are looking at its appearance and feeling its surface.

Shape is very important in changing the form of most standard stock. Shape may be changed in two basic ways: (1) forming and (2) separating.

Forming can change the internal or external form of standard stock. Forming does not add or remove any material. Forming is done in three ways: (1) casting or molding, (2) compressing or stretching, and (3) material conditioning.

Separating removes excess material from standard stock or parts. Separating is done in three ways: (1) shearing, (2) chip removing, and (3) processing by the use of heat, chemicals, or electric current.

Parts can be made from standard stock by forming or separating, or both. After parts have been made, they can be joined together to make more complex products. Joining parts is called combining (assembling).

The designer must choose materials that will work in the product. Some materials are better processed by forming. Others are better processed by separating. Many parts are made by using both of these processes. When materials are being picked for use in a product, the costs to buy them and to process them must be thought of.

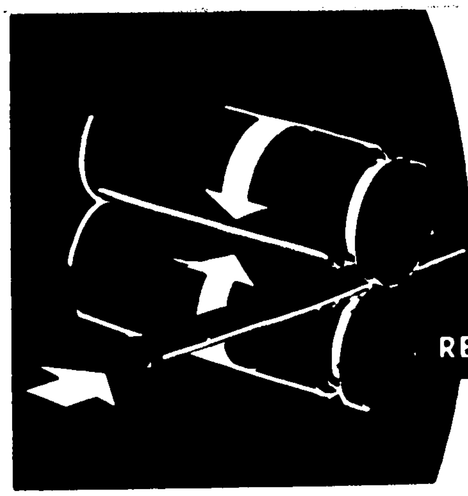
Terms to Know

standard stock
primary industries
process
components
assembled
forming
separating
complex
combining
form
properties
dense
resilient
rigid
viscous
internal
pigs (ingots)
external
remove
excess
casting
molding
compressing
stretching
material conditioning
cavity
plastic (soft)
forging
rolling
compression molding
bending
drawing
press working
thermal conditioning
physical or mechanical deforming
chemical reactions
brittle
removing
shearing
sheared
chips
chip removing
internal processing
tolerances
ingredients
mixed
coated
bonded
adhesives
mechanically fastened
assembly
subassembly
shock resistance
corrosion resistance
ductile

Think About It!

1. Identify two one-piece products around your home that have been manufactured by *forming*. By *separating*.
2. Select any assembled product in your house where most of the parts can be seen. Count the number of parts in the product.

Material Forming Practices



READING 49

In the last reading you learned about two ways to change standard stock into *components* (parts) and one-piece products. These two ways are *forming* and *separating*. You also learned about *combining* parts by *mixing, coating, bonding,* and *mechanical fastening.* In this reading, you will learn more about the three major ways to form standard stock. They are (1) *casting* or *molding,* (2) *compressing* or *stretching,* and (3) *material conditioning,* Fig. 49-1.

A forming process may start with a single piece of standard stock. It may also start with a certain amount of standard stock in liquid or powder form. After any forming process, all the stock is still there, but its form is different. Sometimes more than one forming process is used on a piece of standard stock. Some machines are built to *trim* (form and separate all in one motion) standard stock. In this process, some *excess* (extra) stock has been *removed* (taken off), while the rest has been put into a different shape.

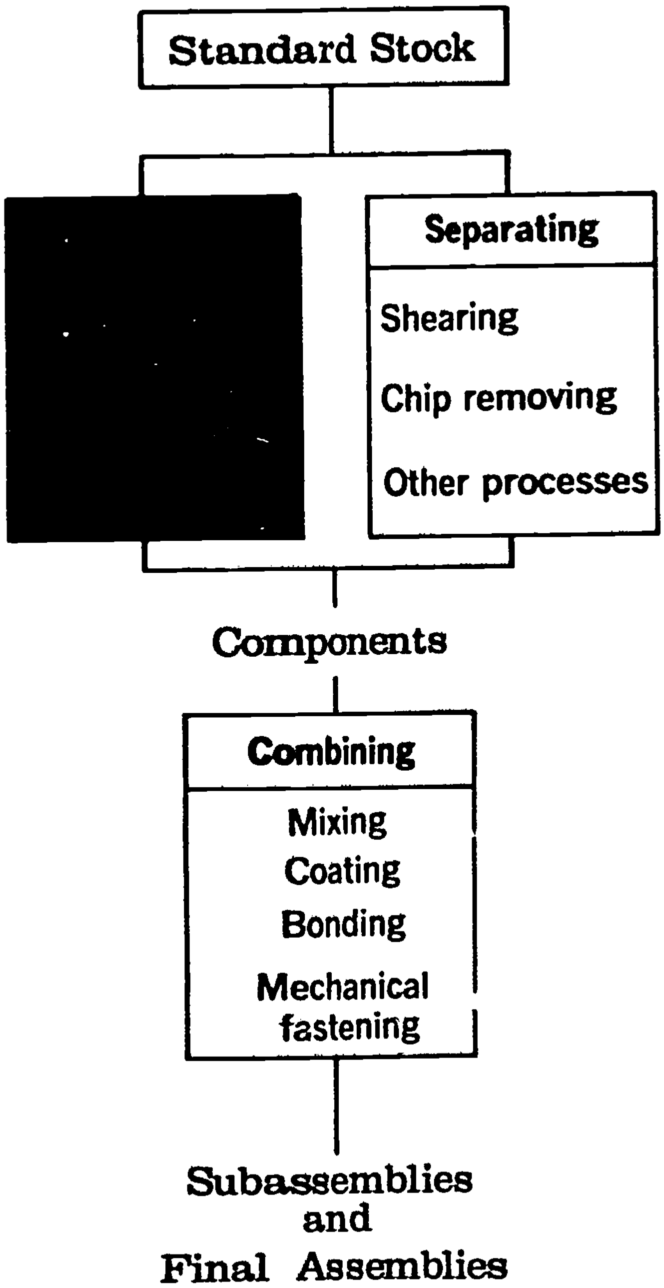


Fig. 49-1. Forming, in the shaded area above, is discussed in this reading.

Casting or Molding

To form standard stock by *casting* or *molding,* products are made in a *mold* or die (a completely enclosed cavity of hollow space). The mold is often made from a pattern that is shaped like the part to be made. The *cavity* (hollow space) will have the exact shape of the part to be made. This kind of mold is made in two or more parts so that the pattern can be lifted out before *molten* (melted) iron, for example, is poured in. Glass, rubber, plastics, and other metals can be formed by casting or molding. The way these molds are made, and materials are

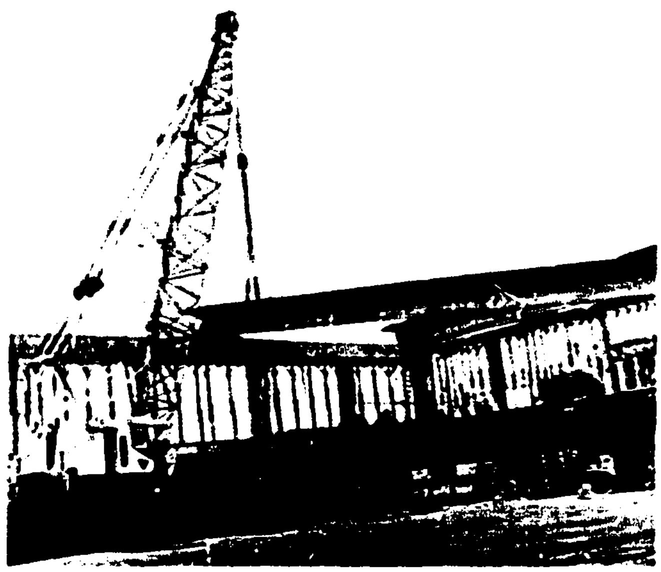


Fig. 49-2. Such products and parts as these prestressed concrete beams are made by casting. The beams are ready to be used when they come out of the mold.

Fig. 49-3. These are cast V-8 car engine blocks. There are 26 separate precision-machining processes that are done to these blocks in this 77′ long transfer machine. This machine completes the manufacture of these parts.

used to make them, differ a great deal. They often depend on the product or part to be formed.

Some parts and products are ready to be used when they come out of the mold or die, Fig. 49-2. Simple plastic toys and glass bottles are examples. Simple products like these need only a little more processing, such as polishing. Not much material is lost in these processes. There are products that need a lot more processing when they come out of the mold or die. A car engine block is a good example. Its basic shape is formed by casting, but there are many separating processes, such as precision-machining, that are needed to complete the manufacture of this part, Fig. 49-3.

In casting or molding some parts or products, the mold can only be used once. These are called *one-shot molding processes.* Some of these include *sand casting, shell-mold casting,* and *investment casting.* In casting or molding other parts or products, the mold can be used over and over again. These are called *permanent-mold processes.* Some of these include *die casting, slush casting, centrifugal casting, transfer molding, injection molding,* and *lay-up forming.*

In casting, most standard stock comes into the mold as a liquid or semiliquid, Fig. 49-4. The liquid flows into the cavity and takes the shape of its walls. When it cools below its melting temperature, it hardens and comes out in the shape of the cavity.

Compressing or Stretching

There are several ways to *compress* (squeeze) or stretch (pull) standard stock. These are:

1. *forging,*
2. *bending,* and
3. *drawing.*

In each process, the standard stock is forced into another shape while it is in a *plastic* (soft) or solid state. A part already partly shaped may also be formed by each of these processes. The stock may be

Fig. 49-4. In casting, most standard stock flows as a liquid or semiliquid into the cavity of a mold.

formed at normal room temperature, or it may be heated to a temperature below its melting point to make it easier to form.

In *forging*, the standard stock is hammered or squeezed into another shape, Fig. 49-5. Open-die forging and closed-die forging use a *hammering* process. In each, the standard stock is shaped by *impact energy* (force produced by hitting one material with a heavier, stronger one, causing the lighter one to change its shape). On the other hand, a *squeezing* process is used in machine forging, press forging, roll forging, compression molding, and impact extruding. In these, the standard stock is shaped by *continuous pressure* (force produced by steadily pushing a heavier, stronger material against a lighter one, causing the lighter one to change shape).

In *bending*, the standard stock is *deformed* (changed) along a straight-line axis, Fig. 49-6. For instance, the folding of news-

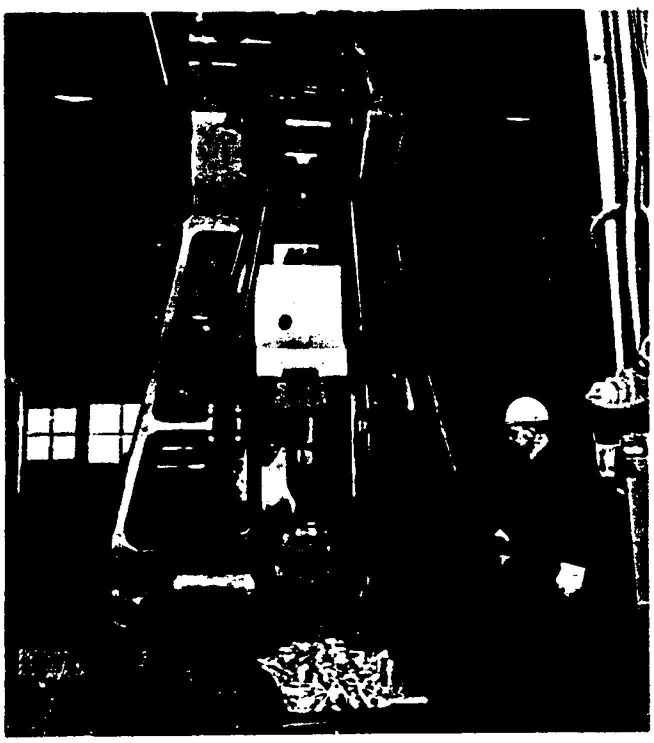


Fig. 49-5. Forging uses impact energy to hammer standard stock into another shape.

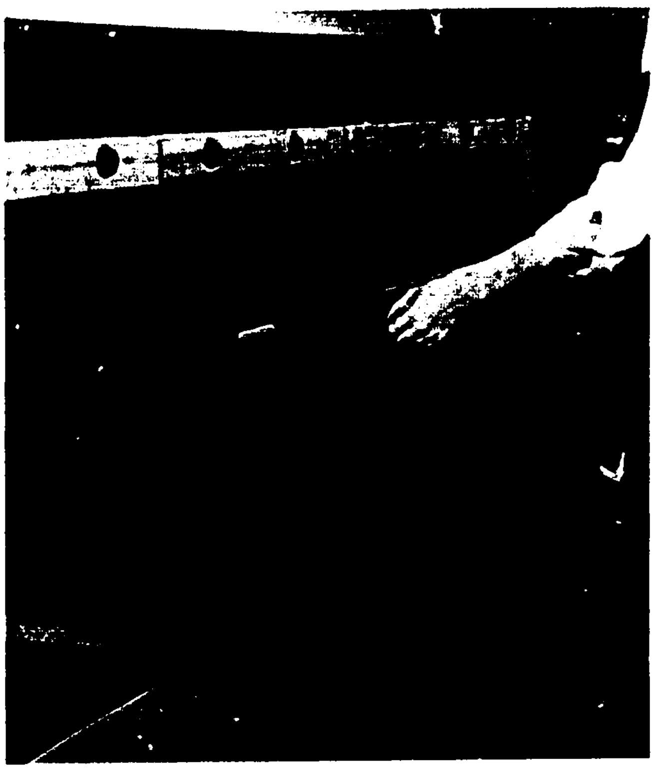


Fig. 49-6. Press brakes are often used to do straight-line axis bending. Notice how the piece of metal stock is being bent. Also note the shape of the dies used in this press.

Fig. 49-7. Many plastic parts are made by vacuum-forming. This is one of the drawing processes.

Fig. 49-8. These plates have been conditioned by controlled heating in this furnace. The external features of the plates are the same as they were before heating, but the internal features of each plate have changed.

print sheets into newspapers is a bending process. Bending includes folding, die bending, and roll bending.

Drawing metal or plastic *stretches* (pulls) the standard stock into another shape without changing its thickness too much. Drawing can make many odd shapes that cannot be formed by bending. The standard stock may be drawn through a single die, or through matched dies. See Fig. 49-7.

Forging is different from bending and drawing because forging changes all three *dimensions* (length, width, and thickness) of the standard stock. In this way, it is similar to casting. Bending and drawing simply reshape the standard stock without changing its thickness very much.

Conditioning Material

To *condition* a piece of standard stock means to change its *properties* (features) so that no one can tell from looking at it that they have been changed. Thus, some *internal* (inside) features of the stock may be changed. For instance, it may be made less brittle, or easier to cut. The shape and size of the piece are not changed. Some of the internal features of standard stock that may be changed are its hardness, its *ductility* (softness), its *machinability* (how well it can be machined), or its *tensile strength* (how easy it is to pull apart).

There are several ways to condition standard stock. They are:

1. *heat conditioning* (Fig. 49-8),
2. *physical* or *mechanical deforming*, and
3. *chemical reactions*.

All these processes change the internal features of the standard stock, but the change is hard for anyone to see.

Summary

Forming is one of the two basic ways to make parts or one-piece finished products from standard stock. There are three major

ways to form standard stock. They are (1) casting or molding, (2) compressing or stretching, and (3) material conditioning. The process used depends on the part or product to be made.

Often more than one forming process is needed to change standard stock into parts or finished products. In order to complete a part, sometimes it must be formed first and then separated.

In casting or molding, liquid standard stock is poured into the cavity of a mold or die. The liquid takes the shape of the walls of the cavity. When it cools, it hardens into the shape of the cavity.

In compressing or stretching, standard stock is forced into another shape while it is in a plastic or solid state. There are three major ways to compress or stretch standard stock. They are (1) forging, (2) bending, and (3) drawing.

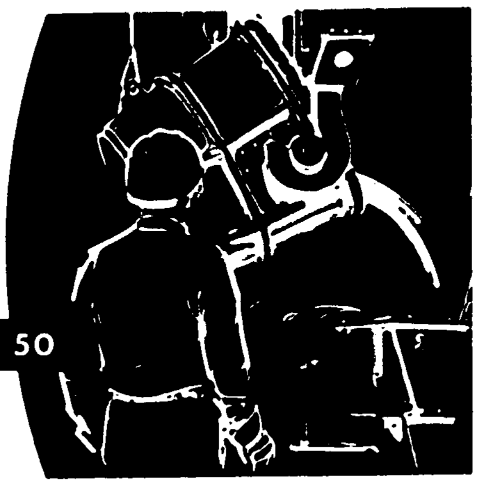
To condition standard stock, some internal feature is changed without changing its shape or size. For instance, steel can be heat-treated, and vegetables can be cooked or frozen. Neither the steel nor the vegetables change size or shape in the conditioning process.

Terms to Know

components
forming
separating
combining
mixing
coating
bonding
mechanical fastening
casting or molding
compressing or stretching
material conditioning
trim
excess
removed
mold (die)
cavity
molten
one-shot molding processes
sand casting
shell-mold casting
investment casting
permanent-mold processes
die casting
slush casting
centrifugal casting
transfer molding
injection molding
lay-up forming
forging
bending
drawing
plastic
hammering
impact energy
squeezing
continuous pressure
deformed
dimensions
condition
properties
internal
ductility
machinability
tensile strength
heat conditioning
physical or mechanical deforming
chemical reactions

Think About It!

1. Can you identify a product or parts of a product that have been formed by *casting* or *molding?* By *compressing* or *stretching?* By *material conditioning?*
2. What products can you find around your home that have been made by *forging?* By *bending?* By *drawing?*



READING 50

Casting or Molding

You have learned that casting or molding is one way to form standard stock. In this reading, you will learn more about how standard stock is cast or molded into *components* (parts) or one-piece products, Fig. 50-1.

The Nature of Casting or Molding

Casting or molding is a forming process in which standard stock in liquid or semiliquid form is poured or pumped into the *cavity* (hollow space) of a mold or die. The liquid takes the shape of the walls of the cavity. It then hardens so that it will keep that shape. The finished piece is called a *casting*, or a *molded part*. It has the size, shape, and surface finish of the mold cavity in which it was made.

The standard stock for casting metal is an *ingot* or *pig*. Plastic standard stock comes in the form of powder or *pellets* (small round capsules). Clay standard stock for casting is a liquid called *slip*. Before solid standard stock can be cast or molded, it must be heated until it becomes a liquid or a semiliquid.

The cavity of the *mold* (die) must be an empty space just the size and shape of the part or product to be cast. Also, workers must be able to get the hardened casting out of the mold, Fig. 50-2. In *one-shot casting*, the mold is destroyed after it has been used only once. In *permanent-mold casting*, the part is made so that it will fall out of the mold after it hardens. That way, the die can be used again to make more parts, Fig. 50-3.

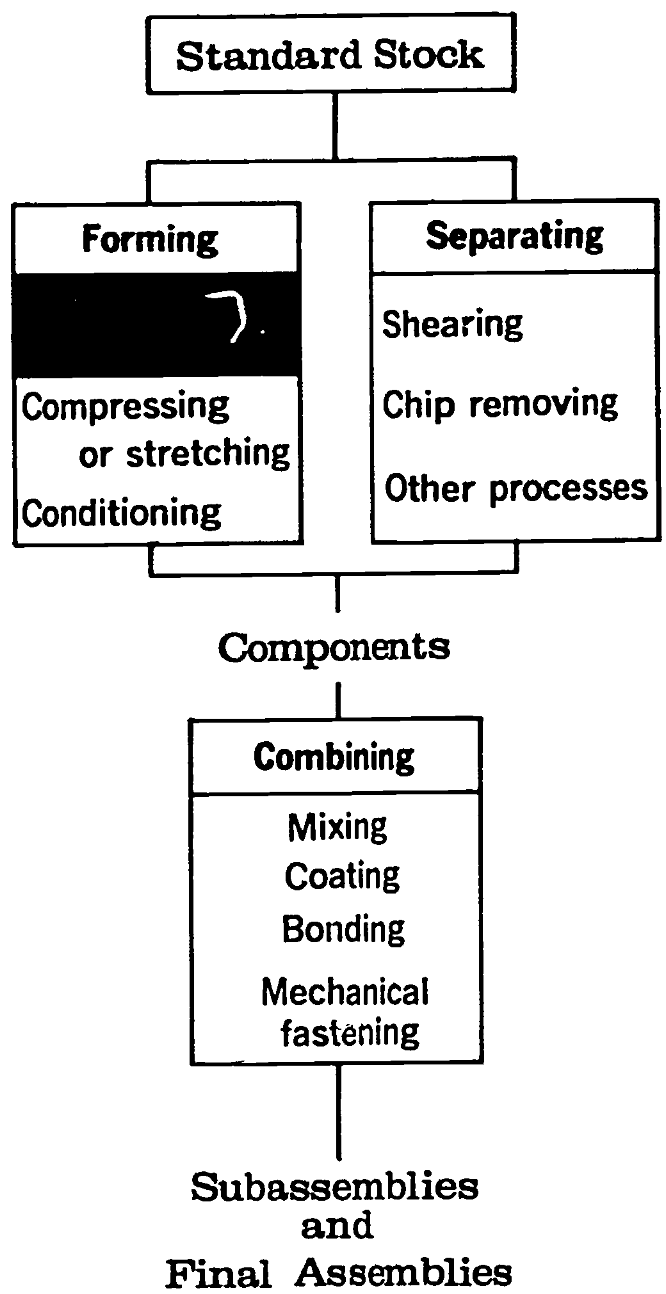


Fig. 50-1. Casting or molding, in the shaded area above, is discussed in this reading.

Examples of Casting or Molding Objects

Casting or molding is a very good way to make a great number of products. Parts and products made by casting include car tires, plate glass, concrete and cinder blocks, and false teeth. Since the shape of a casting depends on the cavity in the mold, several different sizes or shapes are sometimes cast from one batch of standard stock. For instance, a worker could cast dozens of concrete blocks from one batch of concrete mix. Then if he moved to a different mold, he could cast birdbaths from the same batch of concrete mix.

Concrete and gray iron are almost always cast. Many other materials can also be cast. Nearly all of the metals, dozens of plastics and rubbers, several kinds of glass, and many ceramic clays are cast. Foods like gelatin, processed cheese, ice cream, chocolate, and peanut butter are cast into shapes or into their containers. A cake is a casting, and so is an ice cube.

Fig. 50-2. This casting is being removed from a rubber mold. See how the shape and detail of the casting depend on the cavity of the mold itself.

Some of the materials formed by casting cannot be easily bent or shaped after they harden, Fig. 50-4. Concrete and glass are

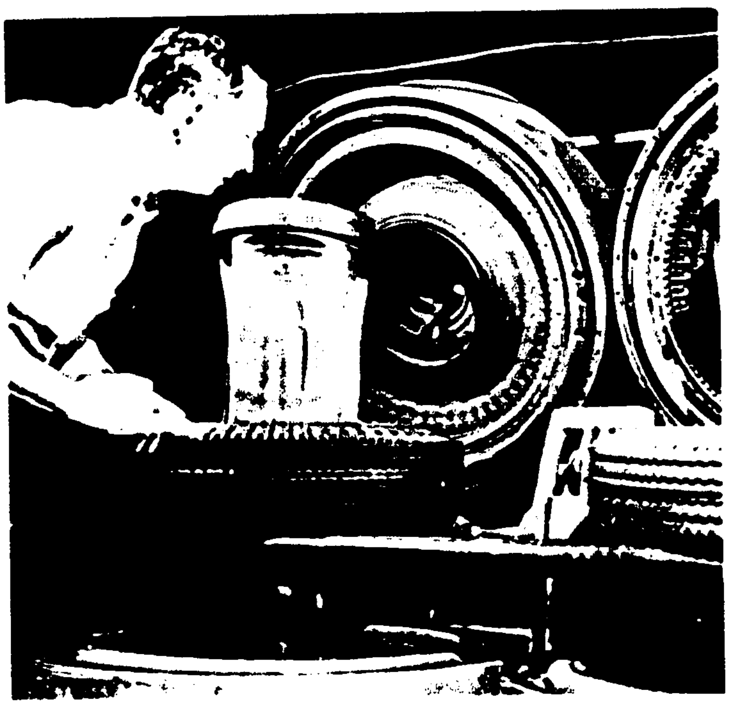


Fig. 50-3. You must open up some molds to remove the molded part. Many tires can be made from this pair of molds.

Fig. 50-4. The prestressed concrete slabs that are being cast in this plant cannot be easily bent or shaped after they harden.

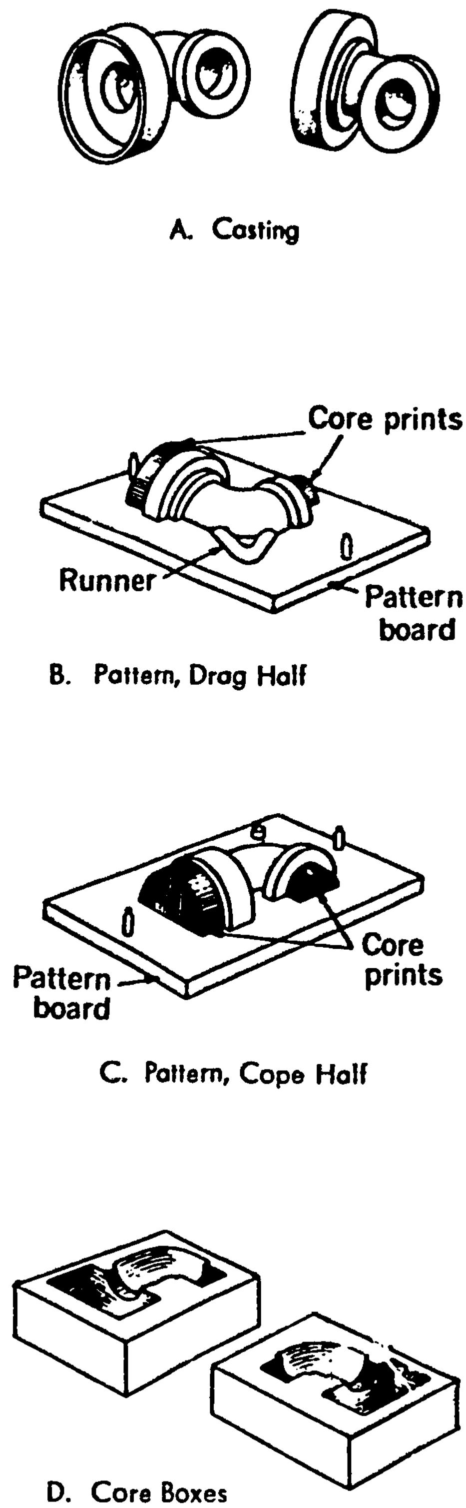
good examples. Other cast materials are so hard they cannot be *machined* (shaped by machine-powered tools). Examples are the very hard metals used to make jet turbine blades, and the clays cast and *fired* (baked) to make chinaware.

Casting can be used to form *complex* (complicated) parts that could not easily be separated from solid blocks or chunks of standard stock, Fig. 50-5. Also, for most standard stock, there is very little waste. *Excess* (extra) metal, wax, plastic, or glass can usually be melted down and used over again to make other products.

One-Shot Casting

A *one-shot casting* is called that because workers have to break the mold in order to get the casting out of the mold. Gray iron and other common metals have been cast in sand molds by a one-shot process for centuries. To understand this process, you should study Fig. 50-6, which shows how a part is cast through a one-shot process.

Fig. 50-5. This mock-up V-8 cylinder head jacket core shows the complicated shape of the product to be cast.

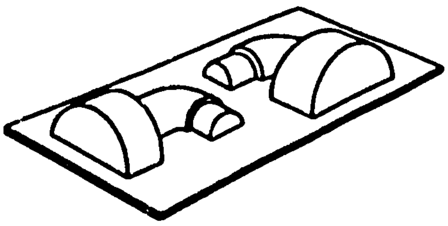


A. Casting

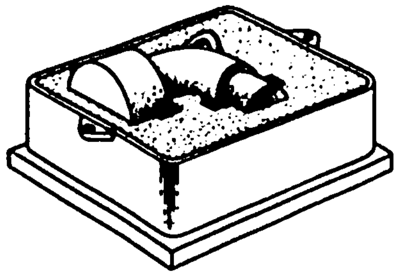
B. Pattern, Drag Half

C. Pattern, Cope Half

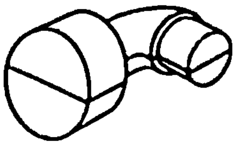
D. Core Boxes



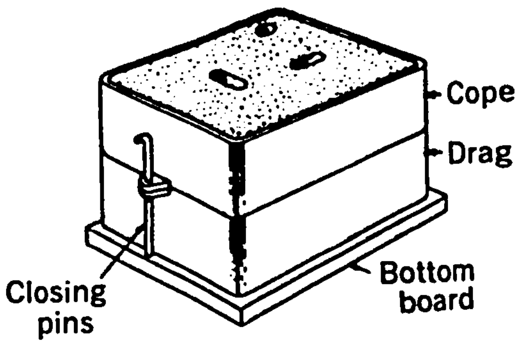
E. Green Cores Ready for Baking



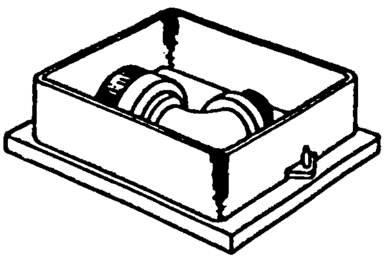
I. Drag with Core Set in Place



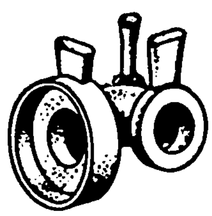
F. Baked Core, Two Halves Pasted Together



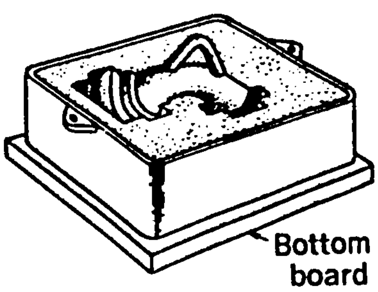
J. Cope and Drag Assembled, Ready for Steel



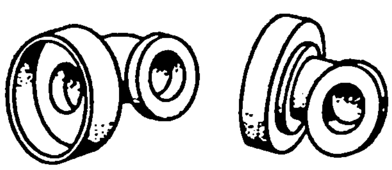
G. Drag Ready for Sand
After ramming with sand, bottom board is set on top of flask, flask inverted, and pattern removed.



K. Casting as Removed from Sand
Risers and gate will be removed, casting chipped and ground where necessary, annealed, and ready for shipment.



H. Drag, Pattern Removed



L. Casting

Fig. 50-6. This set of drawings shows how a one-shot casting is made with a core mold.

Suppose a plant manufactured castings like the ones shown in Fig. 50-6(A). First, a patternmaker makes a *pattern* out of wood. It has the general shape of the part to be made. It is made in two parts: the bottom part called the *drag half,* Fig. 50-6 (B), and the top part called the *core half,* Fig. 50-6(C). Then he makes *core boxes,* Fig. 50-6(D), in which the *core* would be made. The core boxes are filled with a mixture of sand and resin, Fig. 50-6(E). The core is then baked, and the two halves are fastened together, Fig. 50-6(F).

To make the mold for the casting, the worker rams a wet mixture of sand and clay around the pattern. This mixture is held in a two-part box, the drag half of which can be seen in Fig. 50-6(G). When ramming is complete, the halves of the mold are taken apart carefully. Then the pattern can be taken out, Fig. 50-6(H), and the core fitted into the space left by the pattern, Fig. 50-6(I). A pouring hole (*gate*) and vent holes (*risers*) are dug through the core half of the mold, Fig. 50-6(J). Then the pattern and core are put into the drag half of the mold, and the two halves are put back together with closing pins, Fig. 50-6(J).

As soon as the mold is pinned together, the iron is poured into it. Later, the hardened casting is shaken out of its sand mold, and the core sand is dug out of the holes, Fig. 50-6(K). The "stalks" of metal in the pouring hole and vent holes are cut off and sent back to the melting furnace. The mold is now in the shape of the casting to be shipped and sold to customers, Fig. 50-6 (L).

There are many different kinds of sand casting. *Shell-mold casting* is a very precise technique in which sand mixed with powdered resin is dumped onto a hot metal pattern. The heat *fuses* (blends together) some of the resin. The sand is *bonded* (held together) and forms a strong shell. Castings made this way are smooth, precise, and strong. These castings are then fitted together, along with cores. The mold is set into a casting box, and metal shot is packed around it to add strength. Then the metal is poured in. The shell-mold technique is precise enough to use in casting car engine crankshafts, which must be very straight and well balanced.

An even more precise kind of one-shot casting is called *investment casting,* Fig. 50-7. A wax pattern is made very carefully, *coated* (covered) with a ceramic paste, and *embedded* (buried) in plaster. After the paste and the plaster have set, the whole pattern is baked. The wax melts and runs out. Any *residue* (material left over) is burned out. Finally, molten metal is poured into the cavity, duplicating the pattern exactly. This costly technique is used, for instance, to make jewelry, turbine blades, and dental fixtures.

Permanent-Mold Casting

Some castings use the same mold over and over again, Fig. 50-8. These molds are

Fig. 50-7. Investment casting makes very precise parts. Precise casting makes further separating processes unnecessary. The rotor blades of this turbine are cast of a very hard metal. The blades could not be made precisely by any other process.

permanent (long-lasting) ones that can be used for casting parts that are needed in large numbers, like tires, auto trim, gears, toys, and even typewriter frames.

Die casting of metals and injection molding of plastics are *permanent-mold processes.* The liquid or semiliquid standard stock is squirted, under pressure, between two halves of a steel mold called a *die.* The die halves are water-cooled so that they chill the casting quickly. Then they open automatically and mechanical fingers take out the part. The process is completely *mechanized* (done by machines), and dozens of parts per minute can be made. The "tree" of plastic parts in a model battleship kit shows how an injection mold is used, Fig. 50-9.

There are some interesting special kinds of permanent-mold castings. Railroad wheels are cast in carbon molds that are stacked up like phonograph records. Water and sewer pipes are cast inside a fast-spinning tube. The tube spins so fast that the liquid iron is forced by *centrifugal force* (pushing the iron outward from the center of the spinning tube) into the hollow shape needed for the pipes.

Hollow china cats, ceramic wash basins, and toilet stools are cast from a thin mixture of clay and water called *slip.* The mold is made of a material that will *absorb* (soak up) water from the slip. The slip stays in the mold until the water in the slip next to the mold is soaked up into the mold. Then this part of the slip hardens. The mold is then tipped over, and the remaining wet slip is poured back out. This leaves a hollow casting. Ceramic piggy banks are made in the same way.

The Foundry Industry

Until the 19th century, there was very little steel. Parts too large to hammer out of *wrought iron* (tough commercial iron) had to be cast from gray iron. Other ways of casting have been developed since, but the *foundry* (plant where metals are cast)

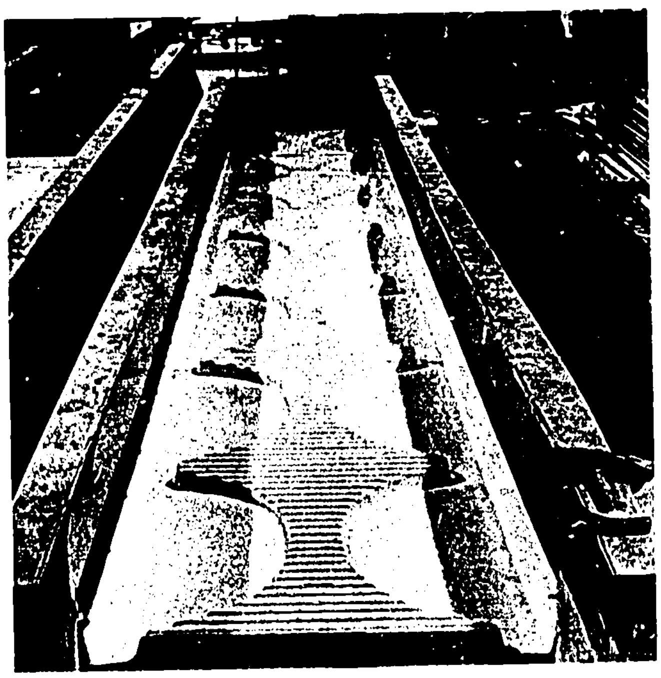


Fig. 50-8. In permanent-mold casting, the castings are removed without breaking the mold. This concrete beam mold can be used over and over again.

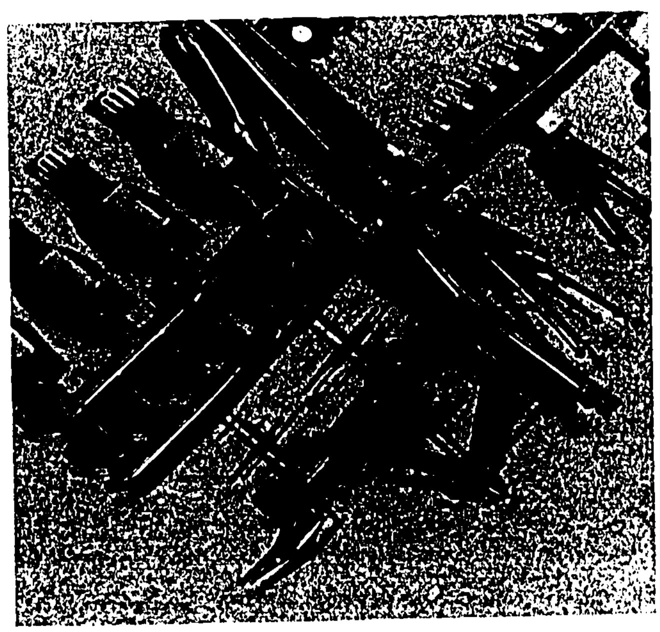


Fig. 50-9. Many plastic toys come in kits with the cast parts still attached to a "tree." These parts can be broken off the "tree" and put together to make a toy battleship. Can you find the gun turrets for the ship?

industry is still important, especially in Pennsylvania, Michigan, Ohio, and Illinois. Some of the smallest successful industries are the foundries, simply because some kinds of castings are needed in small lots, Fig. 50-10. One-man brass foundries and ten-man iron foundries are still very common. Larger foundries make parts to order. They may employ up to a thousand men and be highly mechanized. The making of a single pump housing for a nuclear submarine, though, is still an all-day job for ten good men.

Some plants that use castings in their products have their own foundries. The largest foundries in this country are those in auto plants. There is more cast iron in a modern car than any other metal, except steel.

Large foundries often *specialize* (do one process or make one product). For instance, they may pour only certain grades of metal, or make only such castings as bathtubs or turbine blades. If a buyer wants irregular cast iron in shell molds, there are perhaps only a dozen plants that do this kind of casting.

Successful foundries need men with skills automated machines do not have. Automation can do those jobs which do not affect the quality of the casting. Handling sand, molten metal, and new castings can be done by machines. But men with skills that machines cannot do are needed for precise melting, molding, and patternmaking, Fig. 50-11.

Other Casting Industries

Casting most plastic, glass, and rubber products is done by machines much more than is sand-casting metal parts. This is mainly because permanent molds can often

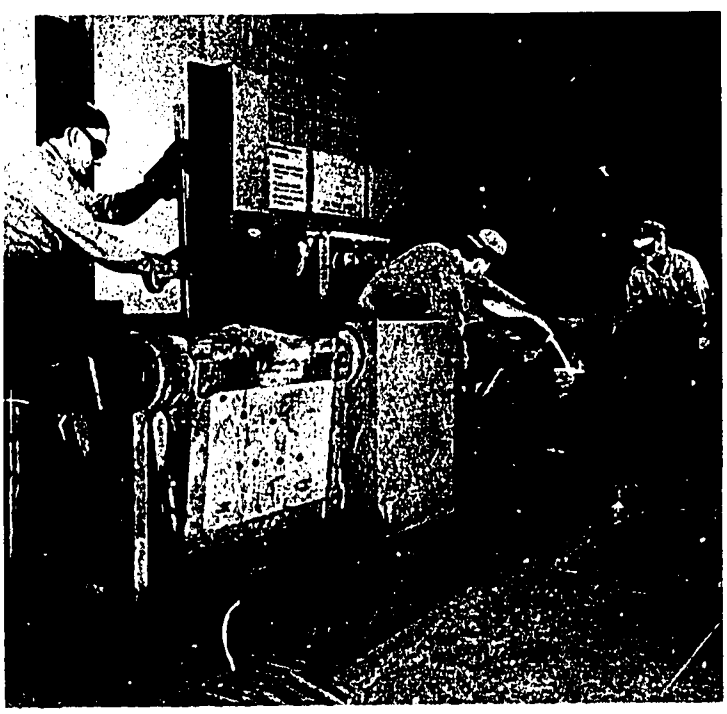


Fig. 50-10. Small foundries are still important in this country. They often cast small numbers of parts by hand-pouring. Here, metal is being poured from the furnace into a crucible. The men will carry the crucible from the furnace to a mold and hand-pour metal into the mold.

Fig. 50-11. The skilled molder is valuable because of his "feel" for the sand as he rams it against the pattern.

be used. A bottle machine can cast thousands of bottles in a single hour. A new plate glass process with fully automatic controls can cast liquid glass on a bed of molten tin to get nearly perfect flatness. In many ways, the new fast-casting processes and machines seem to have increased the need for *skilled men.*

Summary

In casting, molten metal is poured or pumped into a cavity in a mold or die. The cavity has the size and shape of the part to be made.

If the mold must be broken in order to get the casting out of the mold, the process is called one-shot casting. It is used to form metals into precise shapes. Permanent-mold casting uses the same mold over and over again, often on a fast automated casting machine.

Most standard stock can be cast. Thousands of products are made by casting. Skilled die-makers, patternmakers, and molders can find work in many different industries.

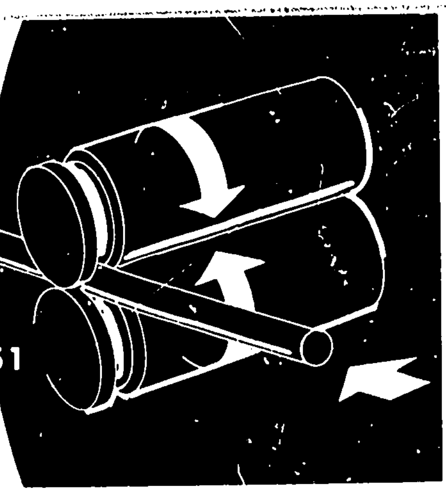
Terms to Know

components
cavity
casting
molded part
ingot
pig
pellets
slip
mold (die)
one-shot casting
permanent-mold casting
machined
fired
complex
excess
pattern
drag half
core half
core boxes
core
gate
risers
shell-mold casting
fuses
bonded
investment casting
coated
embedded
residue
permanent
permanent-mold process
die
mechanized
centrifugal force
absorb
wrought iron
foundry
specialize

Think About It!

1. Can you find three products in your home that have been made by a casting or molding process?
2. Of these products that have been cast or molded, which of them have been done by a *one-shot casting process?* Which have been done by a *permanent-mold casting process?*

READING 51



Compressing or Stretching

You have learned about the forming processes of (1) casting or molding, (2) compressing or stretching, and (3) material conditioning. In this reading you will learn more about forming by compressing and stretching processes, Fig. 51-1.

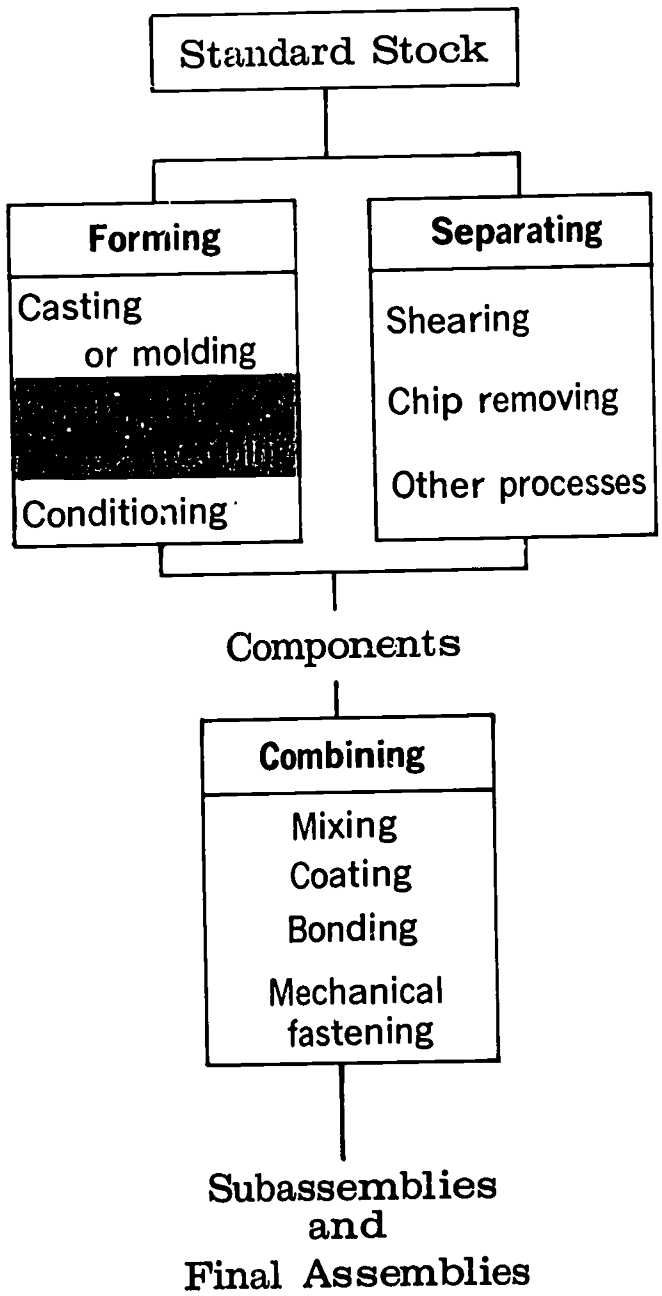


Fig. 51-1. Compressing or stretching, in the shaded area above, is discussed in this reading.

Meaning of Compressing or Stretching

The following examples should help you understand the difference between compressing and stretching. Rolling changes the thickness of pie dough by *compressing* it (flattening and thinning it). When a rubber band is slipped around a package, its shape is changed by *stretching* it (extending it without breaking it). With a rubber band, most of the *deformation* (change of shape) is *elastic* (temporary). The rubber band usually returns to its original shape when the stretching forces are *released* (let go). *Plastic deformation* (material does not return to its original shape) continues even after the force that caused it is released.

Solid materials are said to be *plastic* if their shape can be changed permanently without breaking them. Many man-made materials and some natural solid materials can be permanently shaped. Therefore, they are known as plastic materials. (This use of the term *plastic* should not be confused with its use to describe the new organic materials known as *plastics.*) They are easily shaped when they are soft. They become stronger after they have hardened. In general, metals become weaker and more plastic at higher temperatures. Therefore strong metals are often heated before they are compressed or stretched. Success in forming thus depends on the material, on

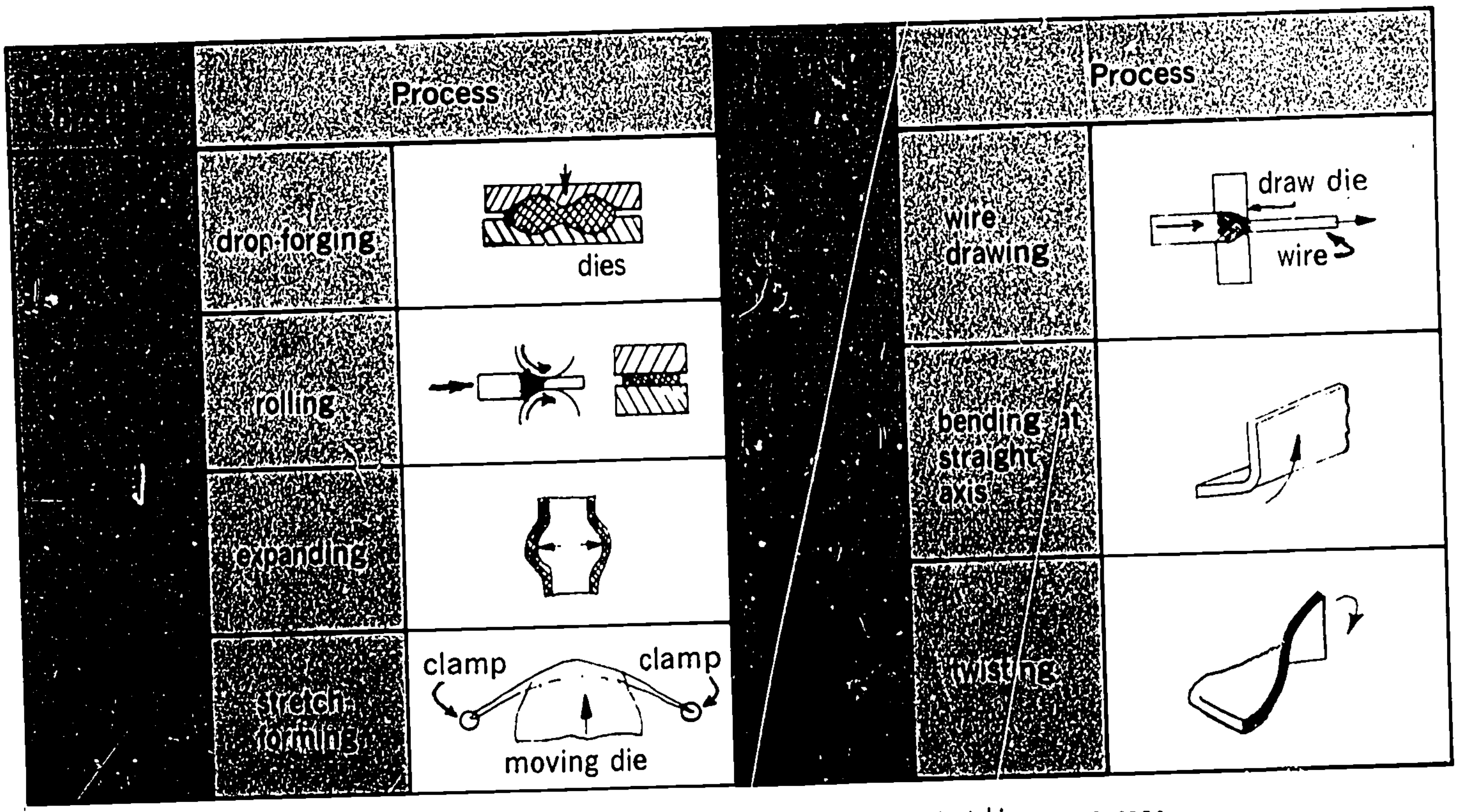


Fig. 51-2. This chart shows several kinds of compressing or stretching processes.

the forming temperature, and on the type of process used.

Compressing or stretching processes may be grouped according to the forces which change the shape of the material, Fig. 51-2. Some processes compress materials. Other processes stretch materials. Sometimes, a forming process may compress and stretch the material in the same process. *Forging* and *rolling* are examples of forming by compressing. *Expanding* and *stretch-forming* are processes that use *tension* (stretching). *Drawing, bending,* and *setting* processes combine the forces of compressing and stretching.

Processes may also be thought of as hot-forming or cold-forming ones. *Cold-forming* of materials is usually done at normal room temperatures. *Hot-forming* is usually done at temperatures far above room temperature, perhaps from 1000° to 1500°F.

Cold-forming increases the hardness and strength of materials. Hot-forming does not change these properties. The temperature separating hot-forming from cold-forming differs with each material. The difference between hot-forming and cold-forming usually depends on the *grain* (texture or structure) of the material.

Dies are special kinds of tools used to change the shape of a piece or a part. A die has a shape that matches the shape of the piece or part to be made. The die to be used in a certain process may be made in one part or in several parts. Dies are most often made from hard metals that have been machined to the right shape.

Importance of Compressing or Stretching

Many common products are made by the forming processes of compressing and stretching. Automobile bodies, metal foil, nuts and bolts, and some plastic containers are good examples. Food products like cookies and spaghetti are also shaped by these same forming processes. Insulating

board and some other types of panels are made by compressing powders or fibers with the right kind of *adhesive* (binder). Decorative patterns can be *embossed* (raised) on silver (Fig. 51-3), paper, leather, and glass by compressing or stretching processes.

Forging Processes

Forging with a hand-held hammer as the moving tool was the first compressing process used in forming, Fig. 51-4. The blacksmith used to form horseshoes in this way. Now the *energy* (force) for forging comes from mechanical hammers or presses. The drop-forging hammer is powered by gravity, sometimes aided by compressed gas or steam. The hammer compresses the stock with repeated blows. In *press-forging*, the ram or die moves more slowly and compresses the metal between the dies in one stroke, Fig. 51-5. Most metals are forged at high temperatures.

Simple or rough forging processes can be done in hammers or presses that have open dies with flat faces. The stock between the dies decreases in height or thickness and increases in width or length as it is flattened and thinned out. Metal changes shape at the spot where the forging hammer strikes it. Between blows, the metal may be moved

Fig. 51-4. One of the earliest compressing processes (forging) used a hand-held hammer as the moving tool.

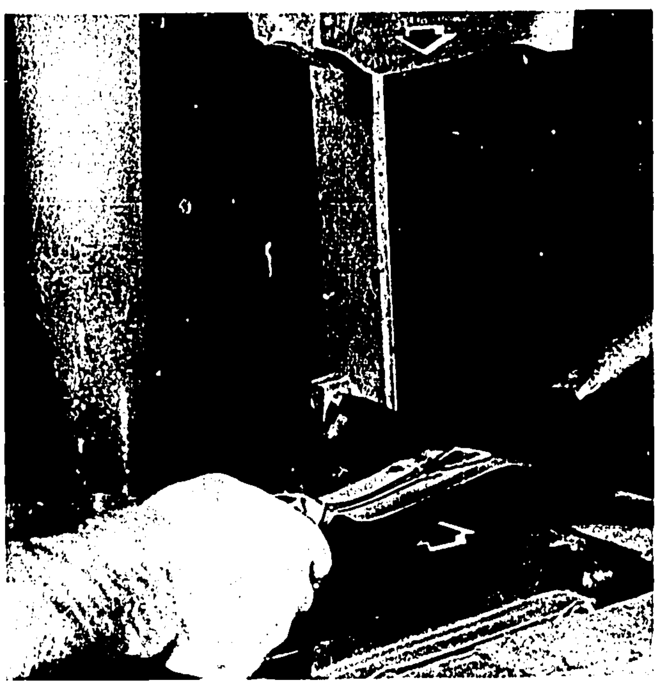


Fig. 51-3. These dies come together to press the design on the front and the back of the handle of this piece of silverware.

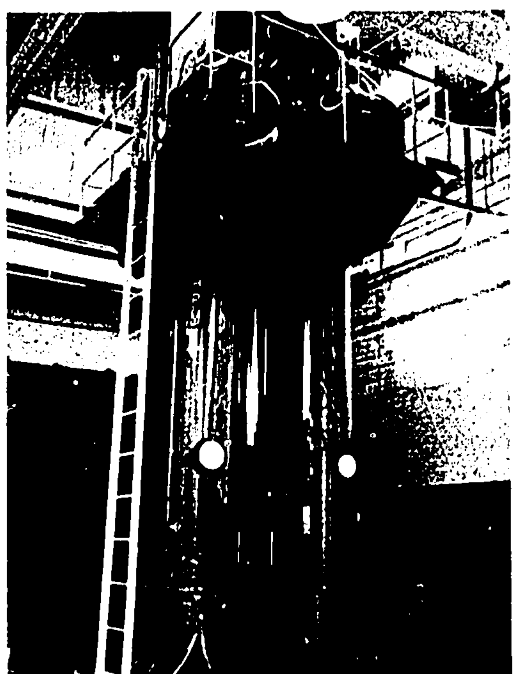


Fig. 51-5. Large forging presses are used to hammer or squeeze parts from standard stock.

or turned to let the hammer strike another spot. More *complex* (complicated) forgings are made by using shaped and matched dies.

Some *components* (parts) are *cold-extruded* (cold-formed) to better control the *dimensions* (sizes) of the standard stock. Toothpaste tubes and other containers are cold-formed from small metal slugs, Fig. 51-6. Because the tool moves at high speed, this process is called *impact extrusion.*

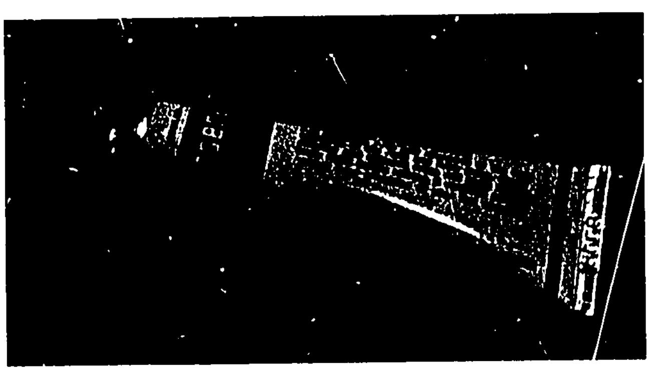


Fig. 51-6. Ointment tubes and other containers are formed by a special kind of forging called *impact extrusion.*

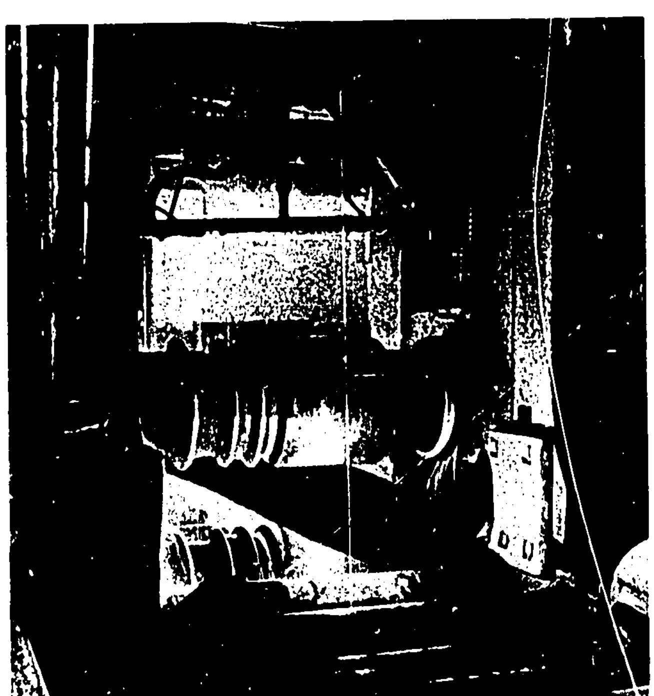


Fig. 51-7. Before metals are compressed and stretched, they are often heated to make them more plastic and easier to form.

Rolling Processes

Compressing can also be done with rotating tools called *rolls. Rolling* is an important way to form standard stock. It is also used to form parts from standard stock. Rolling cuts down the *cross section* (width and thickness) and increases the length of the stock. Rolls with grooves act like dies to make shaped parts. Aluminum foil and many food products are rolled at room temperatures. Heavy metal sections are hot-rolled, Fig. 51-7.

Rolls with cavities with the right shapes can forge finished parts or short, simple shapes for later processing. The dies are either machined in or fastened to the rolls. During each *revolution* (turn) of the roll, a shaped die-opening locks onto the stock, shapes it, and allows it to be taken out of the roll. Fishing rods and tines on pitchforks are products that are roll-forged in this way. See Fig. 51-8.

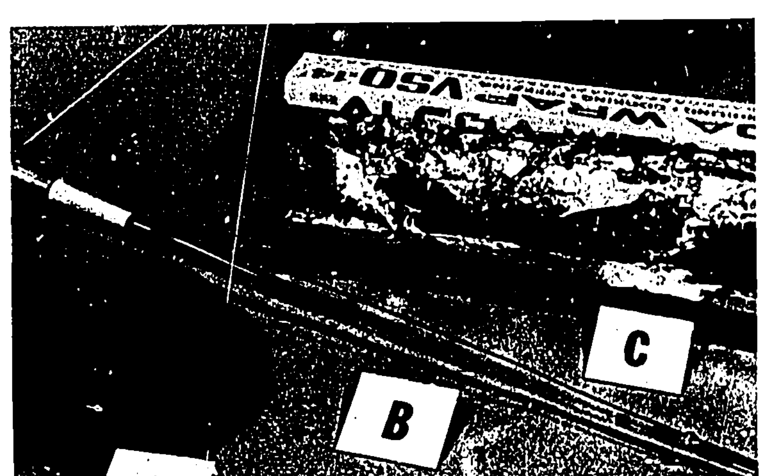


Fig. 51-8. Embossed leather belts (A), tapered fiberglass fishing rods (B), and aluminum foil (C) are all examples of products made by rolling processes.

Compression Molding Processes

Powdered materials are compressed in closed dies to form useful products. The *compression molding process* causes the particles of the powder to come together to form a solid part. See Fig. 51-9. With metal the process is usually combined with *sintering* (heating) to make the compressed part hard and strong. The molding processes you learned about before in Reading 50 are done with liquids or semiliquids. The molding process described here is different because a powder (solid) is used.

Bending Processes

Bending is a simple forming process that causes very little change in the dimensions of standard stock. Different kinds of stock can be bent with the right kind of tools. One part of the tool keeps part of the stock from moving, while the other part pushes the rest of the stock around a forming tool into the right shape. See Fig. 51-10. The material on the outside of the bend is stretched. The material on the inside of the bend is compressed.

Paper clips and wire coat hangers are mass-produced in special bending machines. See Fig. 51-11. Some metal cabinets, boxes, and parts for desks are bent from sheet metal. Folding paper or leather pieces is a bending process.

Drawing Processes

Presses are also used to *draw* or *stretch-form* sheet stock into slightly dished or domed parts, as well as into other simple shapes, Fig. 51-12. The edges of the stock are held tightly while a tool with the right shape pushes at the center. Stretching makes the stock become thinner.

Cups which are deeper than their diameters are made by *deep drawing.* This process is more complicated than stretching. In deep drawing, sheet stock is pushed

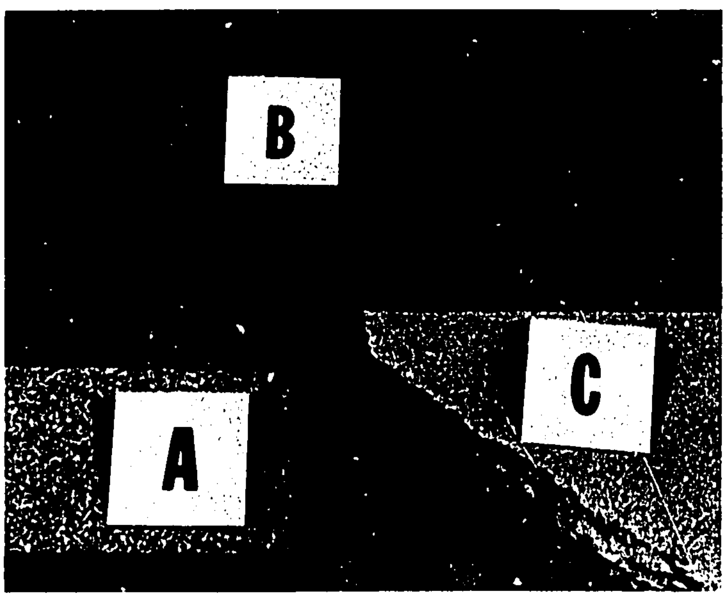


Fig. 51-9. Particleboard (A), hardboard or pegboard (B), and insulation board (C) are made from small wood chips by compression molding. Combining the chips with heat, pressure, and a binding agent makes the product hard and strong.

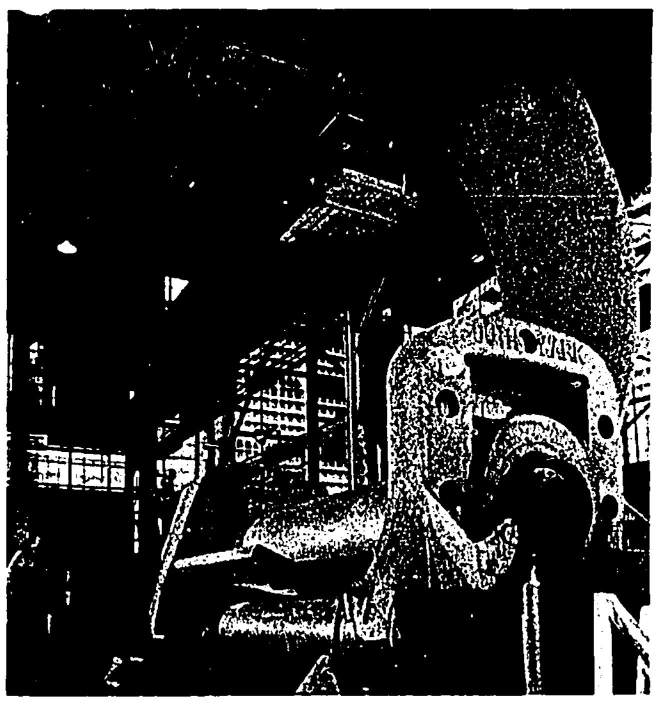


Fig. 51-10. Large slip roll-forming machines are used to bend sheet and plate standard stock into cylindrical shapes.

Fig. 51-11. Small diameter wire or large pipe can be formed into parts by cold-bending processes.

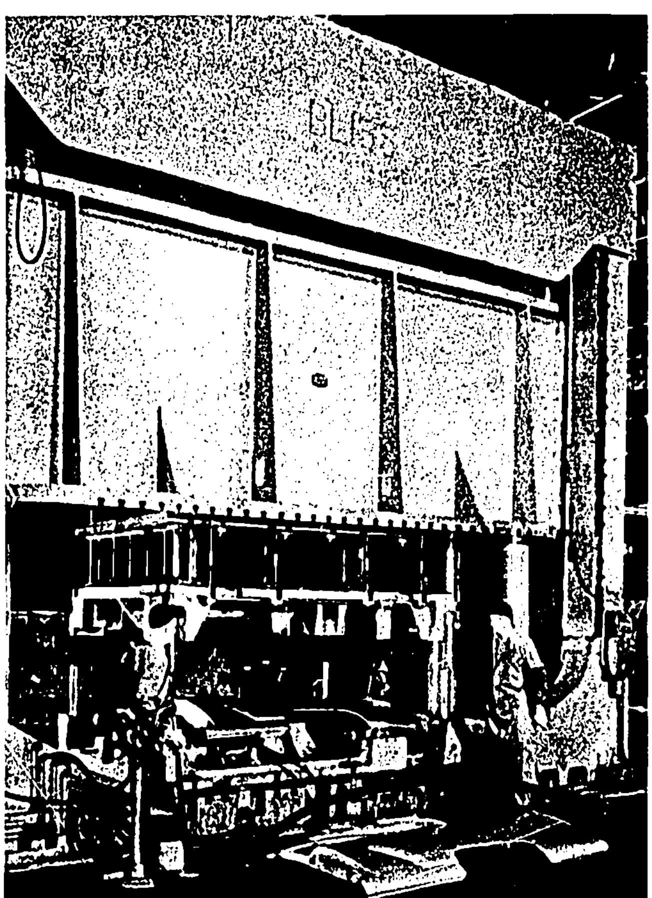


Fig. 51-12. Some automobile parts are drawn by pressing sheet stock between two matched dies. Notice the shaped part on the floor.

through an opening in a die by a central tool or punch. Another part of the tool (called the blank holder) keeps the outer edges of the sheet material from wrinkling. Stretching, compressing, and bending all take place during deep drawing.

Some parts made from sheet stock are drawn with a single die instead of a matched set of dies. Pressurized gas, a fluid, or a rubber pad (instead of a metal punch) forces the sheet stock into the die cavity.

Some metal parts are too large to be made by a press. They are usually made by *explosive-forming*. In this process, a fluid (usually air or water) carries an explosive shock to the stock. See Fig. 51-13. Other sources of energy can be found when presses cannot be used.

Some organic plastics, with low strengths, are *vacuum-formed*. After a vacuum is formed between the stock and the die, air

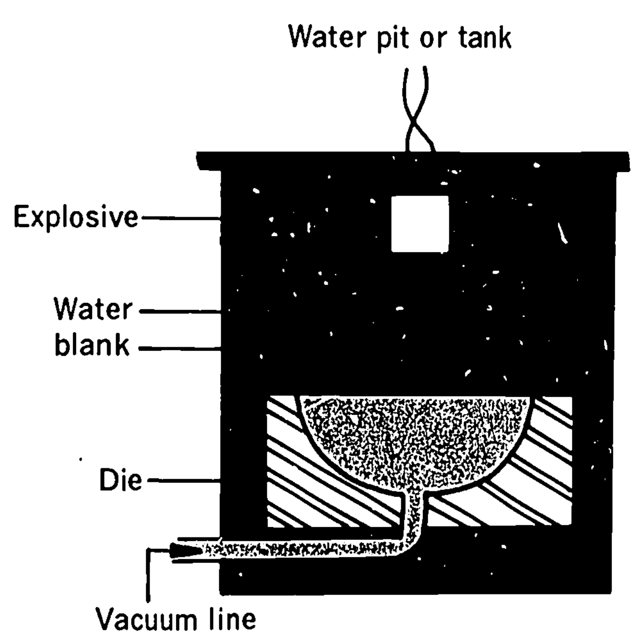


Fig. 51-13. This sectional sketch shows how the explosive-forming process works. Water conducts the force of the detonation shock wave to the blank, forming it against the die.

pressure forms the part, Fig. 51-14. On the other hand, a pressurized gas can be used to blow the stock into the right shape. Glass bottles and other organic plastics are *blow-molded* in this way, Fig. 51-15.

Summary

Some standard stock can be *deformed* (changed) into other, more useful shapes without breaking. Deforming processes compress, stretch, or use combined forces to change the shape of the standard stock. For metals, stretching and compressing may be done by either hot-forming or cold-forming processes. Cold-forming increases the hardness and strength of the stock, but hot-forming does not. Some of the important compressing or stretching processes are forging, rolling, compression molding, bending, and drawing.

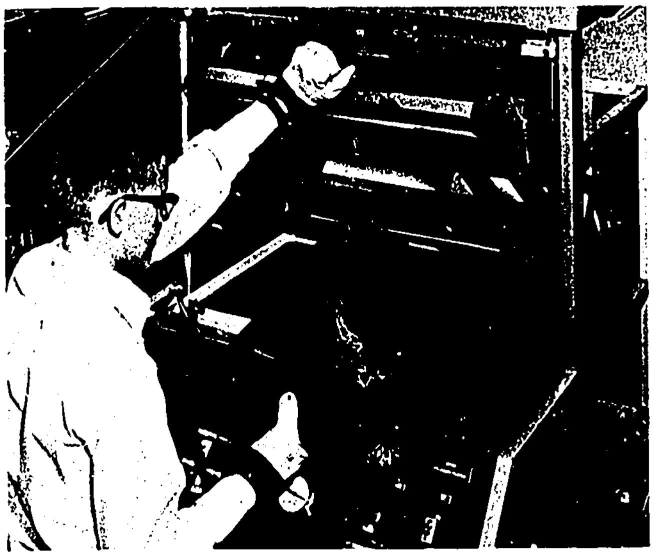


Fig. 51-14. Heat and air pressure are used to form plastic parts by vacuum-forming processes.

Fig. 51-15. Heat and pressurized gas are used to blow-mold many plastic bottles.

Terms to Know

compressing
stretching
deformation
elastic
released
plastic deformation
plastic
plastics
forging
rolling
expanding
stretch-forming
tension
drawing
bending
setting
cold-forming
hot-forming
grain
dies
adhesive
embossed
energy
press-forging
complex
components
cold-extruded
dimensions
impact extrusion
rolls
rolling
cross section
revolution
compression molding process
sintering
deep drawing
explosive-forming
vacuum-formed
blow-molded
deformed

Think About It!

1. In Fig. 51-2, there is a chart that shows several kinds of *compressing* or *stretching* processes. What products can you find around your school that have been made by each of the processes shown in the chart? (Try to think of others than the ones shown on the chart.)
2. How do makers of cookies (or spaghetti) use *compressing* or *stretching* processes in the manufacture of these food products?

Conditioning Material

READING 52

In the last two readings, you learned about two of the three major ways to *form* standard stock. They were (1) *casting* or *molding*, and (2) *compressing* or *stretching*. They make one-piece products or *components* (parts) by changing the shape or *dimensions* (sizes) of standard stock. Thus they make *external* (outside) changes that anyone can see.

Conditioning is the third major way to *form* standard stock, Fig. 52-1. It is done to change the *internal* (inside) structure of the standard stock. Internal changes do not usually show on the outside. Thus they cannot be seen. Conditioning is used to make many different products from many different kinds of standard stock. There are several important ways to condition standard metal stock. This is especially true in making steel.

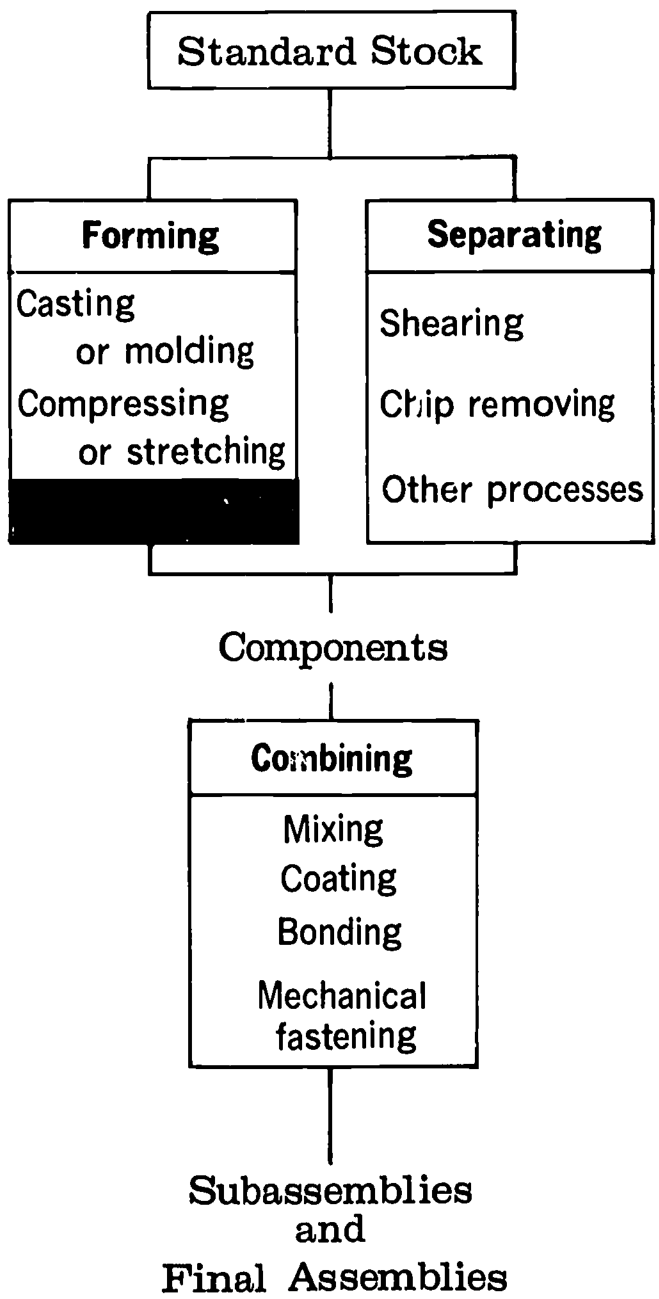


Fig. 52-1. Conditioning, in the shaded area above, is discussed in this reading.

Reasons for Conditioning

There are two major reasons for conditioning standard stock. They are:

1. to make the stock easier to process, and
2. to give the final product some special *quality* or *property* (feature).

Hardness is a feature of standard stock that can often be changed by conditioning. Hardness is important for metal parts that must not wear out fast. Standard stock that will be made into machines does not need to be very hard.

Ductility and *strength* are two other features of standard stock that can be increased or decreased by conditioning. *Ductility* refers to how easily a piece of standard stock can be stretched or compressed. *Strength* refers to how well a piece of standard stock

can stand up under stress or strain. The internal structure of standard stock is made up of small particles called *crystals* or *cells*. In metals, these crystals or cells are called *grains*. When the grains of a metal are round and widely spaced, the metal is ductile and not very strong, Fig. 52-2(A). When the grains are small and flattened out, the metal is strong and not very ductile, Fig. 52-2(B).

Standard stock that is not metal can also be conditioned. Concrete is kept wet during its *curing* process to increase its strength. Clay products are *fired* to bake on surface decorations and to strengthen the clay. Wood products are *treated* (finished) so that they won't wear out quickly, so that they won't *warp* (fold and buckle), and so that insects won't attack them. Food is cooked or frozen to make it more tender, to improve its flavor, or to keep it from spoiling.

Thus you can see that conditioning is done for many specific reasons. There are, though, only two general reasons why standard stock is conditioned. The first reason is to make the stock easier to process. For instance, metals can be conditioned to increase their ductility so that they can be more easily formed and shaped. The second reason is to give some special quality or feature to the stock so that the finished product can do its job better, Fig. 52-3. Strength and hardness are two features that are needed in metal products.

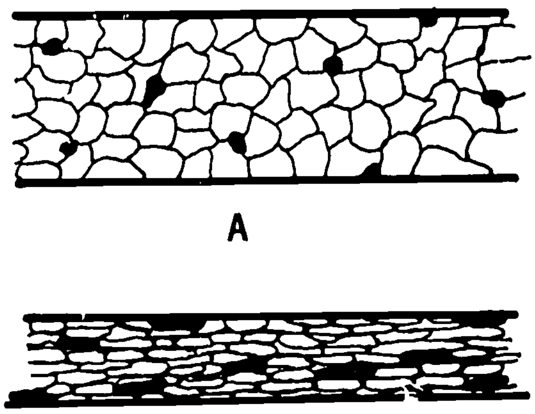


Fig. 52-2. The internal structure of metal is made up of crystals or cells called *grains*.
A. Steel is ductile and not very strong when the grains (particles) are round and widely spaced.
B. Steel is strong and not very ductile when the grains are flattened out.

Conditioning Processes

There are three major ways to condition standard stock. They are (1) *thermal conditioning*, (2) *mechanical deforming*, and (3) *chemical reactions*. In addition, there are several *physical conditioning* processes.

Thermal Conditioning

Heat-treating is the most common kind of thermal conditioning. Heat-treating changes

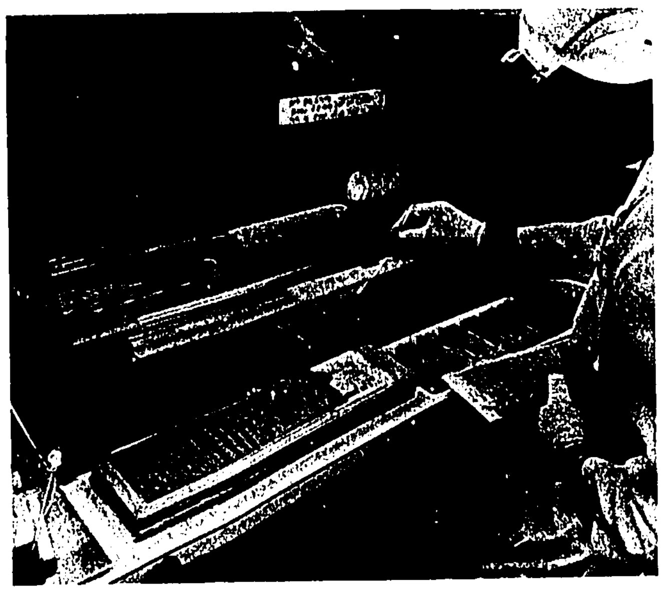


Fig. 52-3. These thin slices of silicon are known as wafers. They are headed for an oven where each wafer will become hundreds of tiny integrated electronic circuits. Each wafer will replace dozens of ordinary parts in electronic systems. In this early step of manufacture, the wafers are placed in a quartz "boat" to be conditioned in an oven at red-hot heat to give them a protective oxide coating.

the features of standard stock by raising or lowering temperatures. The temperature change is *temporary* (lasts only a short time) and is controlled in order to get the right feature for the piece of standard stock. The right temperature, the right rate of heating or cooling to reach that temperature, and the right length of time to keep the stock at that temperature are all controlled very carefully. For instance, coffee is frozen and then dried to make freeze-dried instant coffee, Fig. 52-4.

All metals can be softened by heat-treating. This process is called *annealing.* Aluminum can be annealed at 650°F., copper at 900°F., and most steels at about 1600°F. Most steels must be cooled slowly until they reach room temperature. Aluminum and copper do not need slow cooling in order to keep them soft.

Many steels are *normalized.* In this process, steel is heated to a fairly high temperature (about 1700°F.). Then it is air-cooled. Before a piece of steel is normalized, there are often internal *stresses* (compressing or stretching forces) trapped here and there in the grain structure. Normalizing takes away these spots of stress and spreads iron carbide grains evenly throughout the steel. It can also make steel easier to heat-treat.

Steels are made harder and stronger by heating them to about 1600°F. and then cooling them quickly. The usual technique for cooling is called *quenching.* The steel is plunged quickly into oil or water, Fig. 52-5. Steel hardened this way is likely to be *brittle* (easily snapped), so quenching is usually followed by *tempering.* This technique makes the hardened steel less brittle and more ductile.

Often the *surface* (outside) layer of a product must be very hard so that it will not wear out quickly. At the same time, the *core* (underlying metal) must be tough so that the product can stand hard blows and

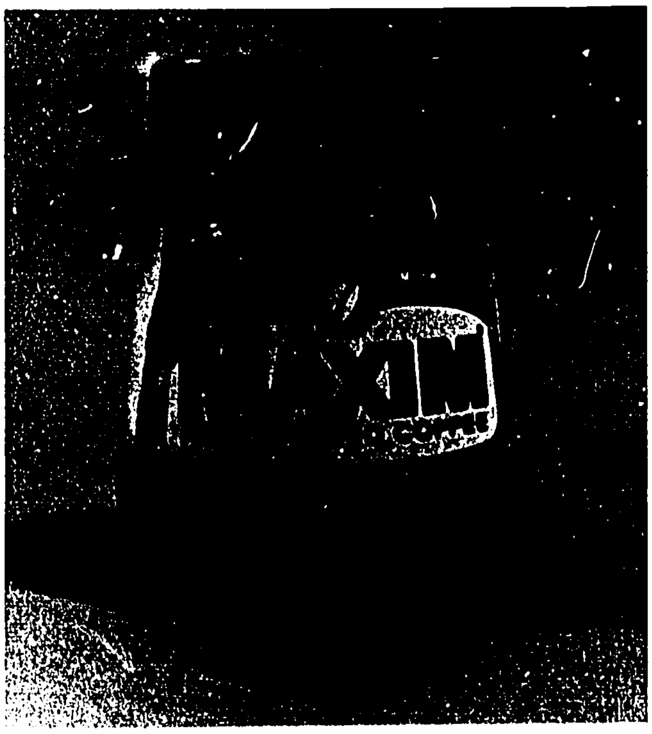


Fig. 52-4. Some coffee is frozen and then dried to make freeze-dried instant coffee. This is a thermal-conditioning process.

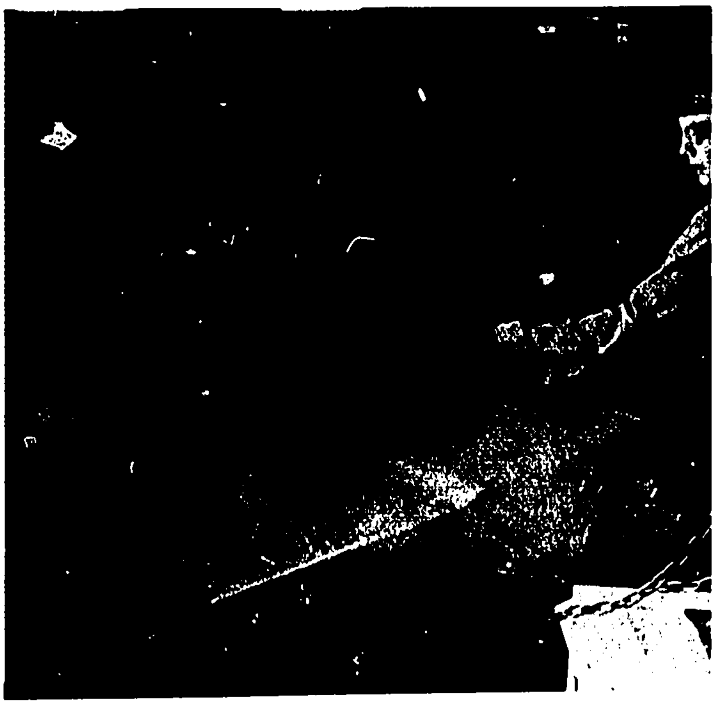


Fig. 52-5. Steel can be hardened by heating it and then quenching it. This technique is done by plunging the steel into oil or water.

much battering, Fig. 52-6. Making a hard surface (*case*) with a tough core is called *case-hardening*. Only the outer layer (case) is raised to the hardening temperature. This is done in a special carbon gas. The core itself is not heated very high, so it stays hard and tough, Fig. 52-7.

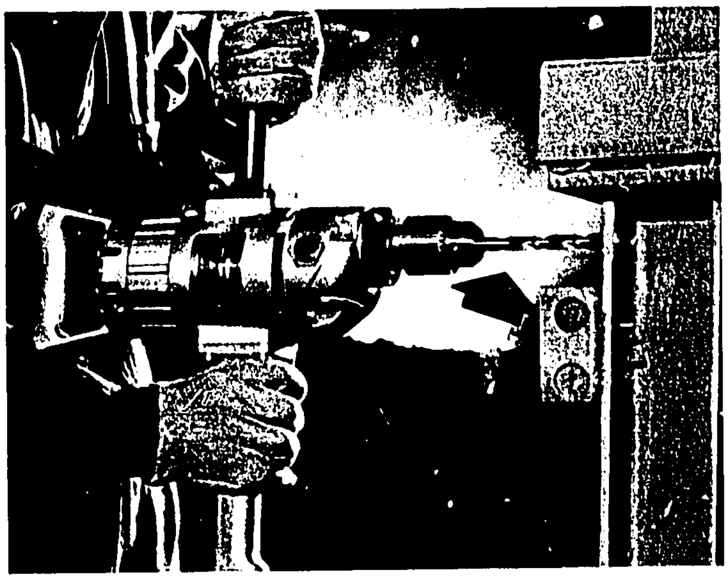


Fig. 52-6. This twist drill was conditioned so that it would be hard enough to drill holes through other materials.

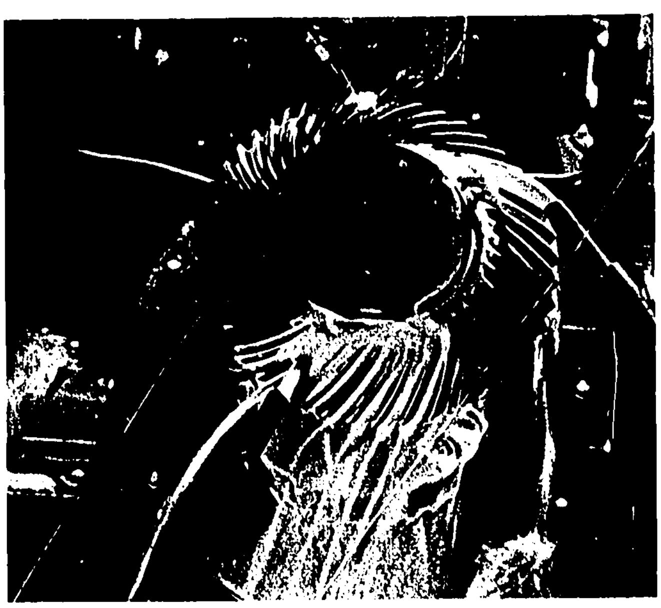


Fig. 52-7. These gear teeth are being flame-hardened. This special kind of case hardening leaves the inside of the gear teeth tough but not brittle.

Mechanical Deforming

Standard stock can sometimes be conditioned indirectly. It is done during some other process that has a very different purpose. For instance, the main purpose of most *mechanical deforming* processes (those that change forms of standard stock by machines) is to form standard metal stock into some part or one-piece product. It turns out that the metal stock is often conditioned while it is being formed, Fig. 52-8.

If mechanical deforming is done at high temperatures, it is called a *hot-working process*. If it is done at room temperatures, it is called a *cold-working process*. Hot-working sometimes changes the size of the grains in the metal. Usually the higher the working temperature, the larger the grain size will be. Cold-working will often increase the strength and cut down the ductility of the metal, Fig. 52-9. It is known ahead of time that internal changes like these will take place. The process is not done, though, to make these changes take place. It is done to give the standard stock a different shape.

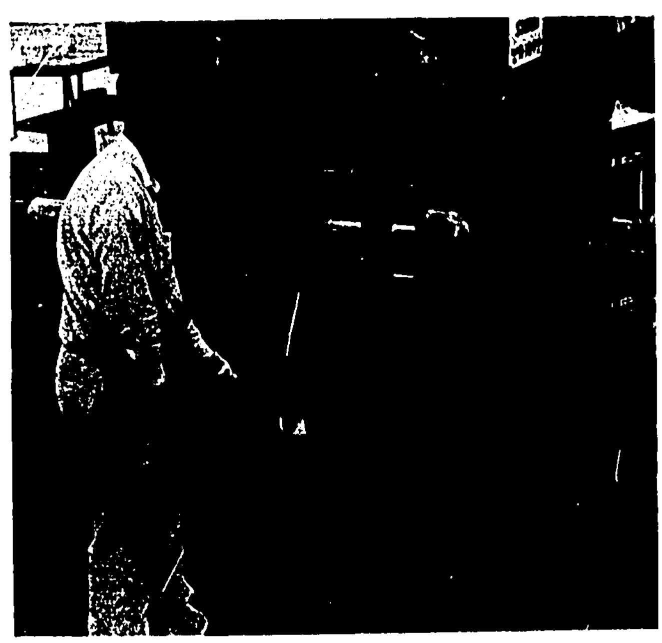


Fig. 52-8. Cold-rolling plates for reactor fuel parts also cause indirect hardening of the material. This is called *mechanical deformation conditioning*.

Chemical Reaction

In a *chemical reaction*, the atoms that make up the piece of standard stock rearrange themselves. When they do, they form products that are chemically different from the original stock. Heat is needed to make some chemical reactions take place. For instance, fruits and vegetables are canned to keep them from spoiling and to make them *digestible* (able to be eaten). The baking of dough for bread, rolls, and cakes is another kind of *thermal* (heat) chemical reaction. Still another kind is the hardening of thermosetting plastics, Fig. 52-10. Other chemical reactions include the tanning of leather and the curing of standard stock by exposing it to radioactivity.

Physical Conditioning

There are only a few physical *conditioning processes* used to make parts or products. For instance, the piece of steel that will become a compass needle must be magnetized before it is *assembled* (put together) with the other compass parts. Magnetizing is a physical change in the steel brought about by a physical process. See Fig. 52-11.

When and Where Conditioning is Done

Some conditioning is done near the start of a manufacturing process. It is done at that time to get standard stock ready for mechanical deforming, machining, or some

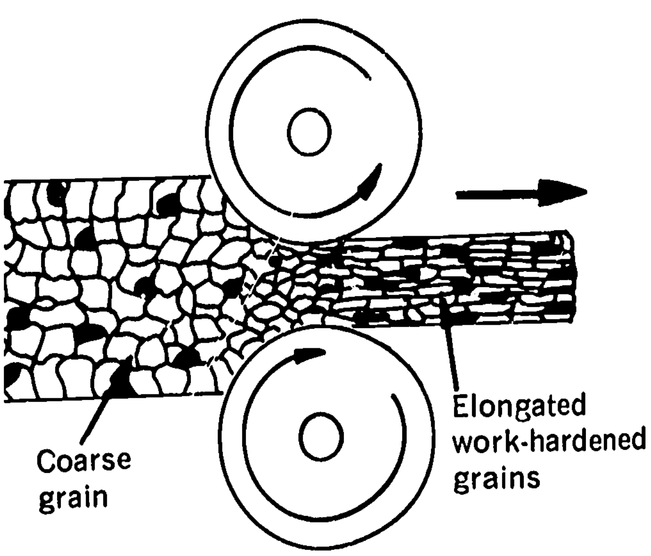


Fig. 52-9. Cold-working usually changes the size and spacing of the grains of the metal. This increases strength and decreases ductility of the metal.

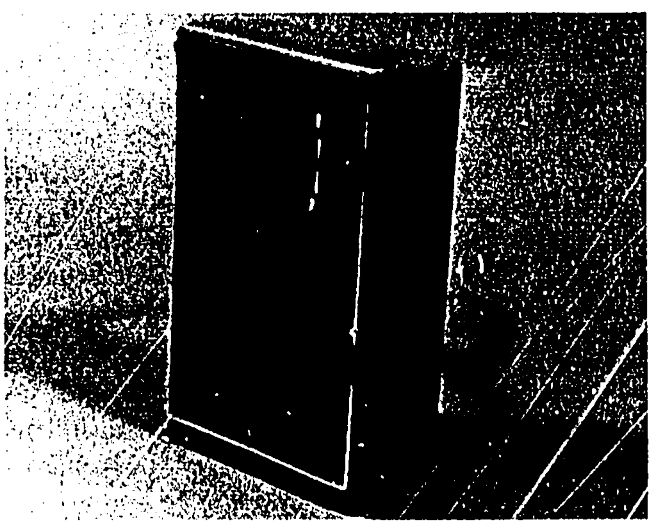


Fig. 52-10. This radio case was formed by a chemical reaction which hardened the thermosetting plastic.

Fig. 52-11. The tip of this screwdriver has been magnetized. This is a physical change in the steel.

other process. Thus steel bar stock that is to be made into parts may have to be normalized before the first machining process can take place. In this case, the conditioning is done near the start of the *manufacturing cycle* (series of production processes).

Sometimes conditioning is done later in the cycle to make forming easier. Often there are several conditioning steps. One example is the *drawing* of complex parts from sheet metal. It may take three draws to make a certain sheet metal part. Each draw leaves the metal very hard and not very ductile. To make it more ductile, the metal is *annealed* (softened) between each of the drawing steps. The full cycle would include these steps: (1) cut blank, (2) make first draw, (3) anneal, (4) make second draw, (5) anneal again, and (6) make third draw. The annealing between draws is an example of *in-process conditioning*. See Fig. 52-12.

Some conditioning is done so that the finished product can better do what it is supposed to. This kind of conditioning is done at, or near, the end of the manufacturing cycle. Hardening the surface of ball bearings to make sure they won't wear out quickly is an example of *end-process conditioning*. See Fig. 52-13.

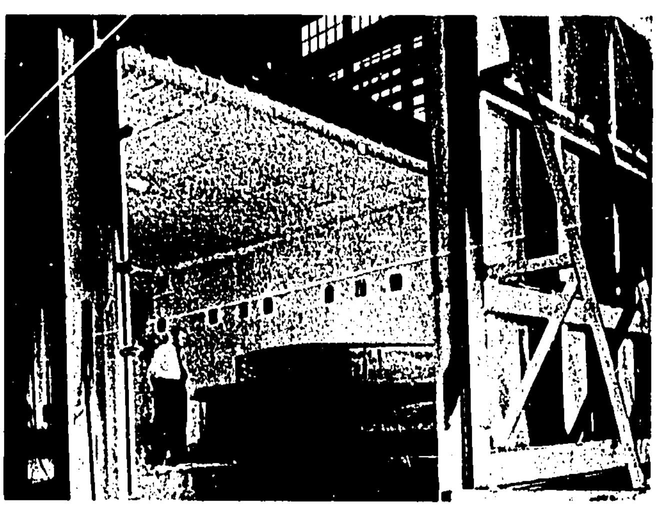


Fig. 52-12. This metal tank part is being placed in an annealing furnace between forming processes. This is an in-process conditioning treatment.

Most in-process conditioning is done by the plant that makes the product. Sometimes standard stock is conditioned before it leaves the plant so that it will be easier to *fabricate* (construct with standard parts).

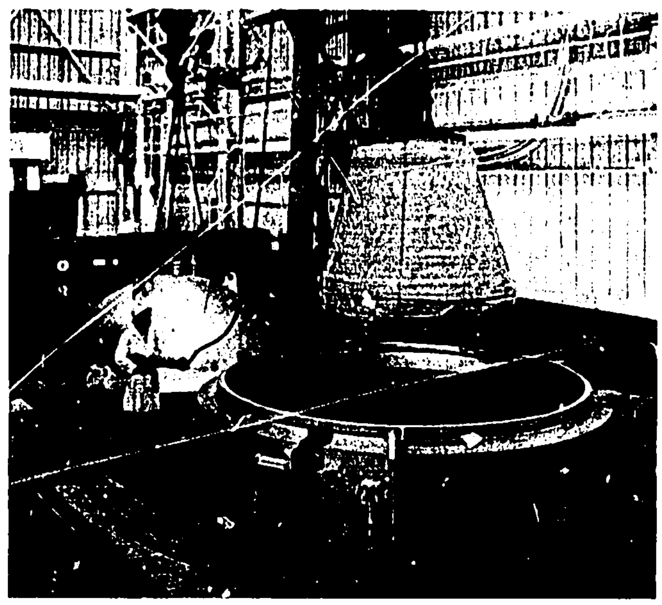


Fig. 52-13. This plastic nozzle liner for a Titan III-C rocket motor enters one of the world's largest hydroclaves to start the cure cycle. This is called *end-process conditioning*.

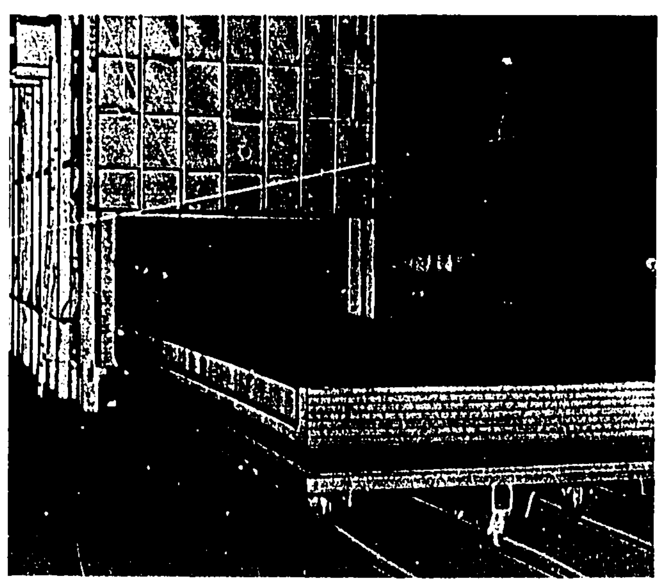


Fig. 52-14. Job heat-treating shops may have many different sizes of furnaces, from very small ones to very large ones.

Heat-treating of metals is often done in *job heat-treating shops*, Fig. 52-14. Nearly all chemical conditioning is done by the processor, not by the supplier of the standard stock.

Summary

Conditioning is a way to form standard stock by changing its internal structure without making any change in its external structure. There are two major reasons why standard stock is conditioned. The first is to make the standard stock easier to process. The second is to give the final product some special quality or feature. The most common ways to condition standard stock are (1) thermal conditioning, (2) mechanical deforming, and (3) chemical reactions.

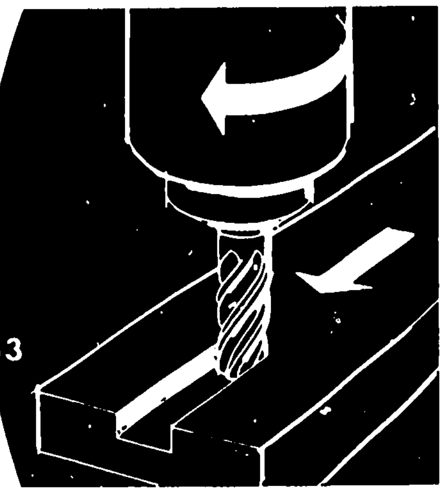
Terms to Know

form
casting
molding
compressing
stretching
components
dimensions
external
conditioning
internal
quality
property
ductility
strength
normalized
stresses
quenching
brittle
tempering
surface
core
case
case-hardening
hot-working process
cold-working process
digestible
thermal
crystals
cells
grains
curing
fired
treated
warp
thermal conditioning
mechanical deforming
chemical reactions
physical conditioning
heat-treating
temporary
annealing
conditioning processes
assembled
manufacturing cycle
drawing
annealed
in-process conditioning
end-process conditioning
fabricate
job heat-treating shops

Think About It!

1. What products around your home have been conditioned by *heat-treating?* By *mechanical deformation?* By *chemical reaction?*
2. What kinds of *chemical reactions* go on in the baking of bread dough? In the canning of fruits and vegetables?

READING 53



Material Separating Practices

In the last three readings, you learned how standard stock is *formed* into parts or finished products. In this reading, you will learn how standard stock is *separated*, Fig. 53-1.

Standard stock must often be separated to make parts or one-piece products. You have learned that there are two ways to change standard stock. They are (1) *forming* and (2) *separating*. You have also learned that parts can be *assembled* (combined) into products with many parts.

The Meaning of Standard Stock Separating

Separating standard stock starts with some piece of stock that is too large in at least one size. It can be *reduced* (cut down) to a part or a one-piece product by *removing* (taking off) the *excess* (extra) stock in some way. For instance, cutting paper is one way to separate standard stock. Sawing a piece of wood is another way. Standard stock can be separated by the use of mechanical force, chemicals, electric current, or heat. You will learn about these techniques in later readings.

The stock left over after the excess has been separated may be as important as the part or product itself. Often the excess can be made into a *by-product*. This can be seen in the making of bottle caps. When bottle caps are *sheared* (cut) from sheet stock, the excess can be used. It might be made into covers for furnace filters.

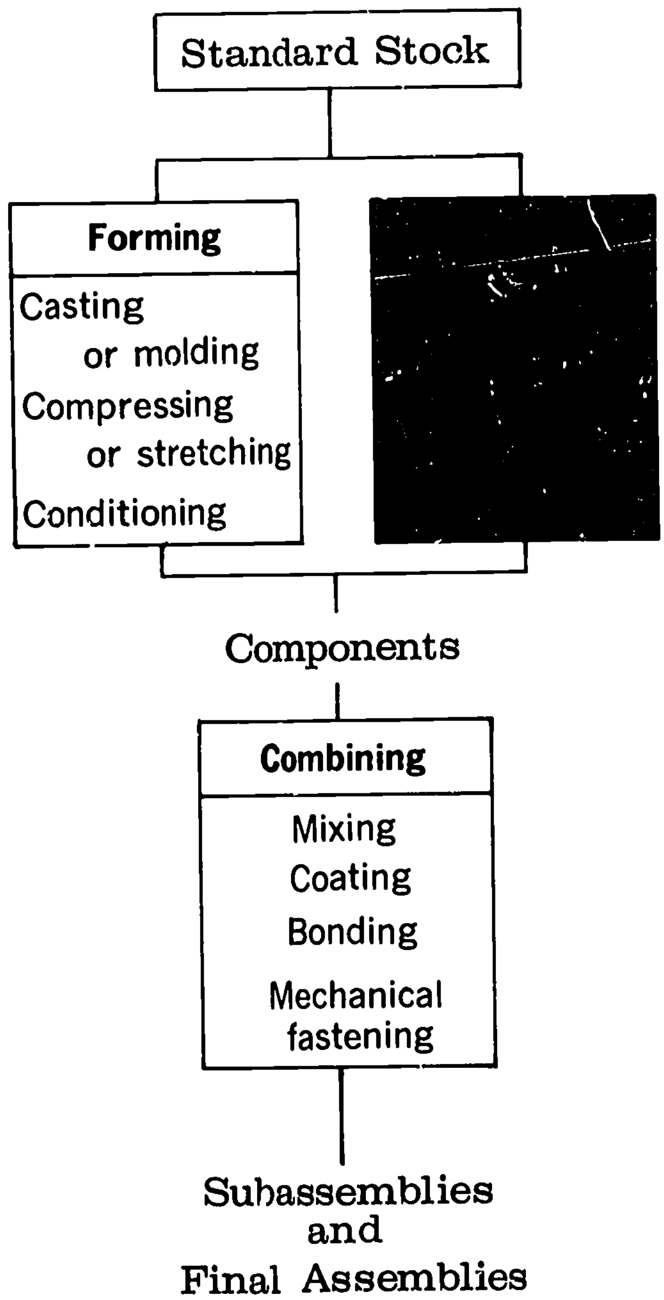


Fig. 53-1. Separating practices, in the shaded area above, are discussed in this reading.

The Importance of Standard Stock Separating

All standard stock is separated at some time in the *manufacturing cycle* (series of production processes). Standard stock can be separated into bulk shapes. Paper, cloth, and sheet metal can be made cheaply in long sheets of standard stock lengths. These can later be cut to any size that is needed.

Major Separating Processes

There are three major ways to separate standard stock. They are (1) *shearing,* (2) *chip removing,* and (3) *other processes.* Each is briefly explained in this reading. You will learn more about them in the next three readings.

Shearing

Shearing (cutting) cuts off *excess* (extra) stock from a piece of standard stock that is too large in at least one size. *Pressure* (force) is put on the cutting edge of a shearing tool, Fig. 53-2. The shearing tool must be harder and stronger than the stock being cut. The stock that is cut off falls away in one piece or in several pieces.

You can cut aluminum with sheet metal shears. You can cut paper with a pair of scissors. You can punch holes in paper with a paper punch. All these are examples of shearing. See Fig. 53-3.

Shearing is often combined with forming. This is done with a wide range of products, from bottle caps to car doors. The sheet stock is *compressed* (or *stretched*) and sheared to the right size at the same time in one machine.

Shearing often *limits* (cuts down on) how much can be cut from a piece of standard stock. What can be cut often depends on the size of the shearing tool and the *cross-sectional area* of the standard stock (thickness of the stock).

Fig. 53-2. Large presses, such as the one shown here, are often used to shear standard stock materials to size. This press will put over 600 tons of pressure on a cutting edge to shear material to the right size.

Fig. 53-3. Two shear operators are cutting thick boiler plates to size with a power press. These plates will later be combined with other pieces into a final assembly.

Chip Removing

Chip removing also takes off excess stock by using pressure on a cutting edge. The excess is taken off in the form of *chips* (small bits or pieces) until all that is left is the standard stock piece in the right shape, Fig. 53-4.

Chip removing is like shearing in one way. When two materials come together and enough pressure is put on one or both of them, the one that is softer or weaker usually gives way. If you put pressure on wood, plastic, or clay with a pocket knife, the softer material (the wood, plastic, or clay) gives way in small bits or chips. If you put pressure on a piece of hardened tool steel with the same pocket knife, the blade of the knife would give way because it is now the softer material.

You can remove chips without costly tools and dies. But chip removing is more wasteful than shearing is. Unless the chips can be used again, the waste becomes costly when millions of parts are being made.

Chip removing can be very precise when you need close *tolerances* (how much the same parts can differ in size and shape and still be used). A centerless grinder used to machine a shaft to a close tolerance is one kind of tool used for precise chip removing. Chip removing does not always need to be this precise. A disk sander removing rust from a car body is one kind of tool used for less precise chip removing. You can cut wood with a saw. You can scrape metal away with a file. You can bore a hole in plastic with a twist drill. You can sand wood with a piece of *abrasive* (rough) paper. You can grind metal with an abrasive wheel. All these are examples of chip removing. See Fig. 53-5.

Other Processes

There are other ways to separate standard stock that cannot be classed as either shearing or chip removing. In recent years, new materials have been found. New and different shapes can be formed with them. To do this, special processes have been developed. They have often been used only on special-purpose, limited-production jobs.

You can use chemicals, electric current, and heat to separate standard stock. Several

Fig. 53-4. Here a drill press operator is removing chips from a piece of steel in a separating (chip removing) process.

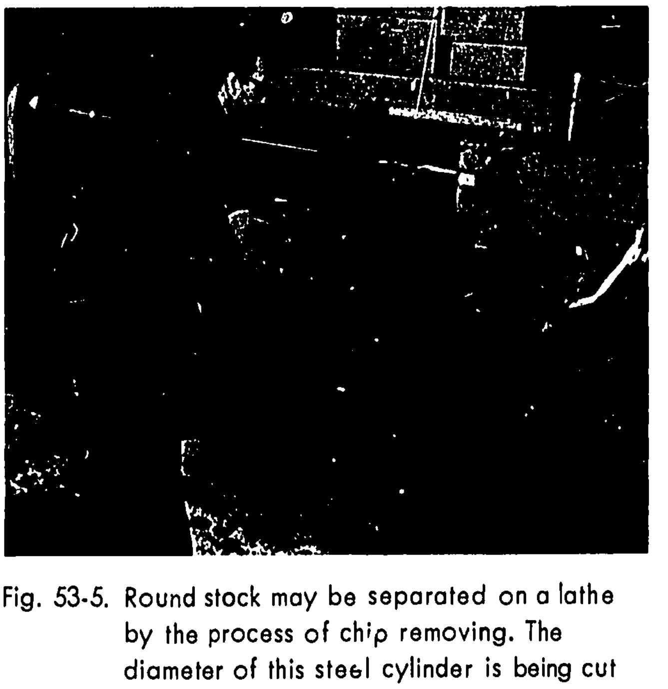


Fig. 53-5. Round stock may be separated on a lathe by the process of chip removing. The diameter of this steel cylinder is being cut down to size by chip removing.

of these ways are being used today. One of them is *thermal erosion* (wearing away by heat). A cutting torch is a tool that uses this technique, Fig. 53-6. Another way to separate standard stock is *chemical separating*. For instance, acid is used to *etch* metal (eat away the metal in a pattern or design). Electric current and chemicals can be combined to separate standard stock. For instance, an alkaline solution can be used to conduct electric current. This process is called *electrochemical separating*. Still another way to separate standard stock is *induced-fracture separating* (using force to make breaks in the stock). Glass-cutting is a good example of induced-fracture separating.

Summary

Separating standard stock is a process that cuts down the size of a piece of standard stock by taking off the excess in some way. All standard stock is separated at some time in the manufacturing cycle. There are three major ways to separate standard stock. They are (1) shearing, (2) chip removing, and (3) other processes. Shearing cuts off the excess stock and leaves the right size and shape. Chip removing takes off the excess stock in small bits and chips. There are chip removing tools that can be used to get very close tolerances. There are other such tools that are used when less precise tolerances are needed. New materials have been found in recent years. New processes have been developed to work with them. Chemicals, electric current, and heat can be used to separate these new materials.

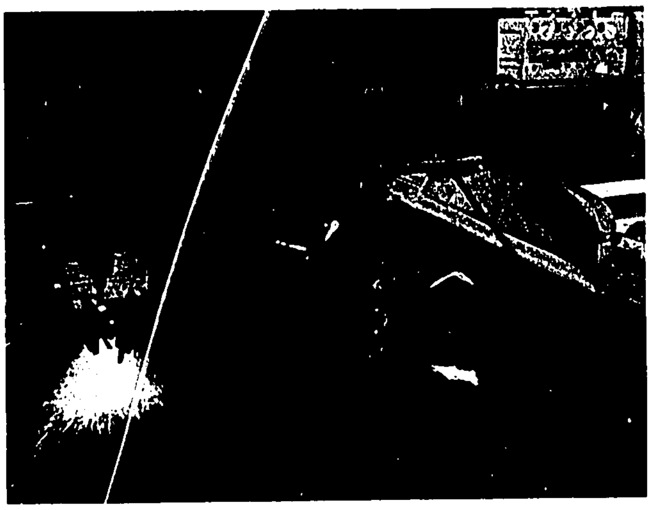


Fig. 53-6. Several pieces of plate steel are fastened together with clamps (left side of picture). A cutting torch using oxygen and acetylene gas is making parts from each plate by thermal erosion.

Terms to Know

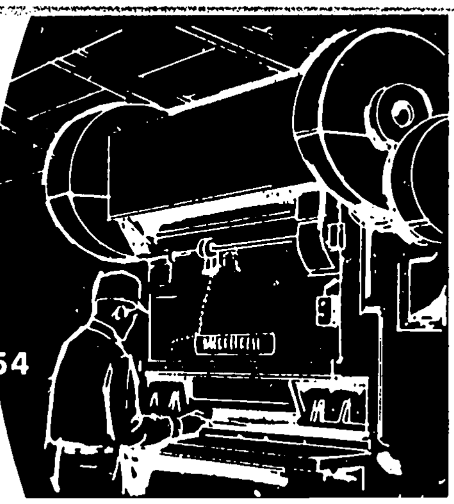
formed	compressed
separated	stretched
forming	limits
separating	cross-sectional area
assembled	chips
reduced	tolerances
removing	abrasive
excess	special processes
by-product	thermal erosion
sheared	chemical separating
manufacturing cycle	etch
shearing	electrochemical separating
pressure	induced-fracture separating
chip removing	
other processes	

Think About It!

1. From the following list of materials, determine which separating process should be used. Should they be separated by shearing or chip removing? Materials: sheet metal, sheet rubber, an iron casting, paper, block of stone.
2. From the following list of separating jobs, determine which separating process would be used to perform each job. Should thermal erosion, chemical separating, electrochemical separating, or induced-fracture separating be used?

   Separating jobs: cut glass for a window pane, burn a hole through metal, etch a design on glass or metal, cut a rough diamond, rapidly eat a hole through metal.

READING 54



Shearing

There are three major ways to separate standard stock. They are (1) *shearing,* (2) *chip removing,* and (3) *other processes.* In this reading, you will learn more about how *shearing* is done, Fig. 54-1.

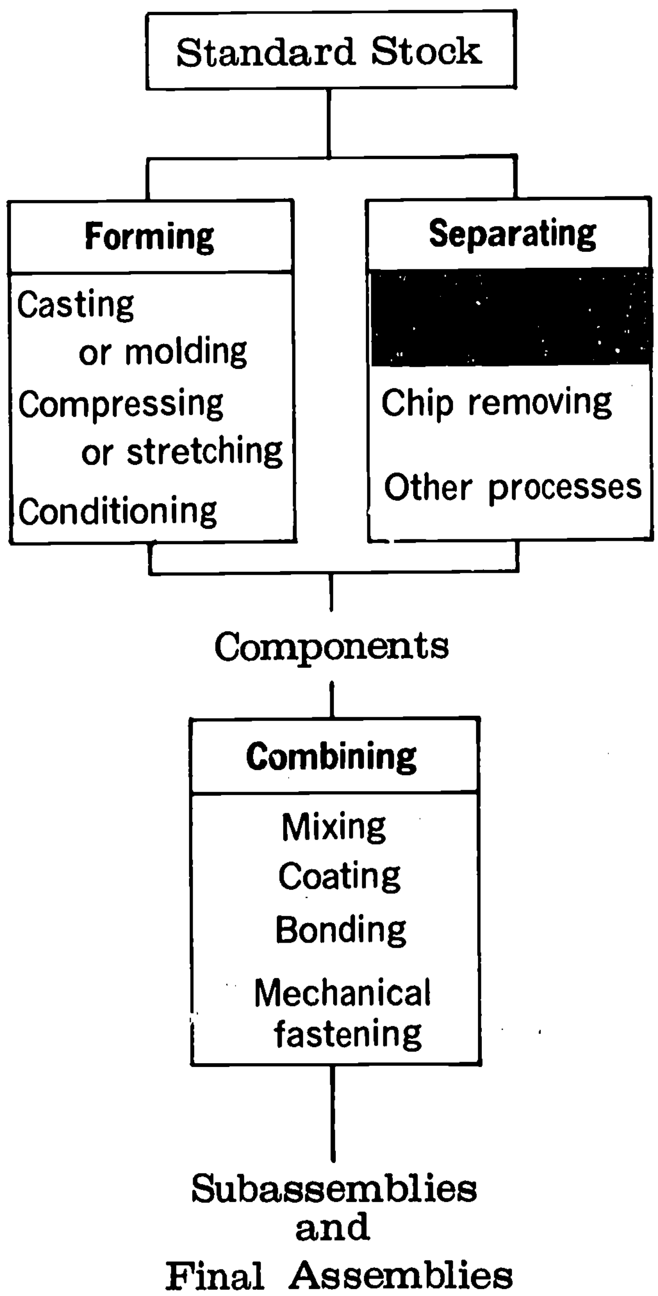


Fig. 54-1. Shearing, in the shaded area above, is discussed in this reading.

Shearing Processes

Shearing is a process that cuts off part of a piece of standard stock. The purpose is to give shape to the stock or to cut it into pieces. There is a basic difference between shearing and *chip removing.* In *chip removing,* small bits or chips of the stock fall away and are lost. In shearing, no stock is lost by crumbling, shredding, or powdering. Also, the excess stock cut off in shearing can often be used to make something else. In these ways, shearing is less wasteful than chip removing.

When Shearing Occurs

Shearing is done at many different times while a part or a product is being made. Paper is taken from rolls and sheared to the right size and shape, Fig. 54-2. Cloth is taken from bolts and sheared to many different sizes and shapes. Metal and plastic standard stock in sheet, bar, and tube form are sheared to the right size by heavy machines. Before wire can be made into nails, it must be sheared to the right lengths. All these materials come to the manufacturer in standard stock lots. All of them must be sheared to the right size and shape before they can be used.

Extruded bricks (those shaped by forcing them through a die) are sheared to the

353

right thickness with a wire tool. Some cookie dough is extruded in a continuous length and then cut into pieces. Both of these materials are sheared *after* some manufacturing processes have taken place, but *before* others have.

Shearing takes place during the final trimming of a magazine. This is the *last* manufacturing process for this product. The handling and shipping that come later are *distribution processes* (ways to get the product to the customer).

All these examples show that shearing can take place at any time while a product is being made.

Shearing to Size and to Shape

Standard stock is often very large, or very bulky in shape. It is made in large sizes and bulky shapes because that is the cheapest way to make it. Shearing cuts standard stock down to sizes and shapes that can be used to make parts or one-piece products.

In shearing stock that comes in sheets or plates, the line that the shearing tool will follow is called the *line of shear*. It may be straight or curved. The first cuttings of standard stock are always *straight-line shears*. Later, angular and curved edges of many kinds can be sheared. Stock can be cut to almost any shape, from a bicycle fender to a lamp shade.

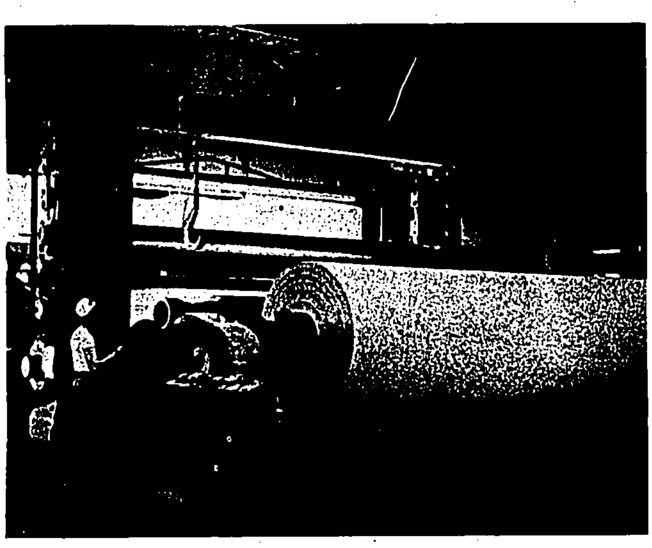


Fig. 54-2. Paper is made in large rolls and later is cut into usable sizes by a shearing process.

Shearing Tools and Operations

Shearing is a process that puts *pressure* (force) on the cutting edge of a shearing tool. The shearing tool must be harder and stronger than the stock that is to be cut. Shearing usually uses a principle known as *mechanical advantage*. This principle involves the use of a machine to *transmit* (pass along) the pressure along the line of shear. With a machine, a large amount of force can be *concentrated* (centered) at one spot on the line of shear. Thus the cut is clean, and no stock is lost or wasted.

The kind of tools and machines used for shearing depends on the kind of stock to be cut. For instance, butter can be sheared with a table knife. To shear sheet steel, you would need hand or power shears with a sharper edge and greater force.

Steel, aluminum, and some other metals have a *high shearing strength*. This means that they are not easily cut. They are often sheared to the right size on power presses, Fig. 54-3. Paper, cloth, leather, and some

Fig. 54-3. Rolls of steel which have been banded together in standard stock lengths are fed into this 100-ton automatic punch press. This press shears out motor parts from the standard stock steel.

plastics are also sheared on power presses. A power press is usually driven by mechanical or hydraulic power, Fig. 54-4.

Machine Operators

Semiskilled or skilled workers usually run power machines. A *semiskilled worker* is one who runs a shearing machine and who from time to time measures the pieces that are being sheared, Fig. 54-5. A *skilled worker* is one who sets up his machine, *aligns* (straightens) the cutters, and measures, adjusts, and *maintains* (keeps up) his machine, Fig. 54-6.

Besides the jobs of those two kinds of workers, there are a large number of other shearing jobs for workers to do. There are also many shearing jobs that need either no worker or very little attention from a worker. For instance, a shearing device can be attached to an extruder that will automatically cut the extruded pieces to the right lengths.

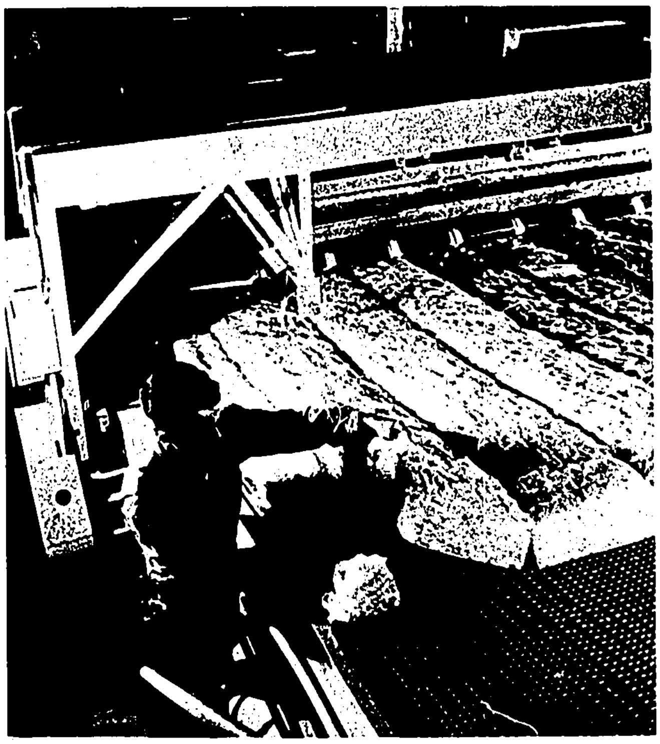


Fig. 54-5. Here, a slicing process is done by a semi-automated shearing machine. Wide sheet insulation stock is fed into the shearing machine which slices it into strips.

Fig. 54-4. Channeling is being sheared to the right length by this machine. Notice the hydraulic cylinder which drives the cutting blade.

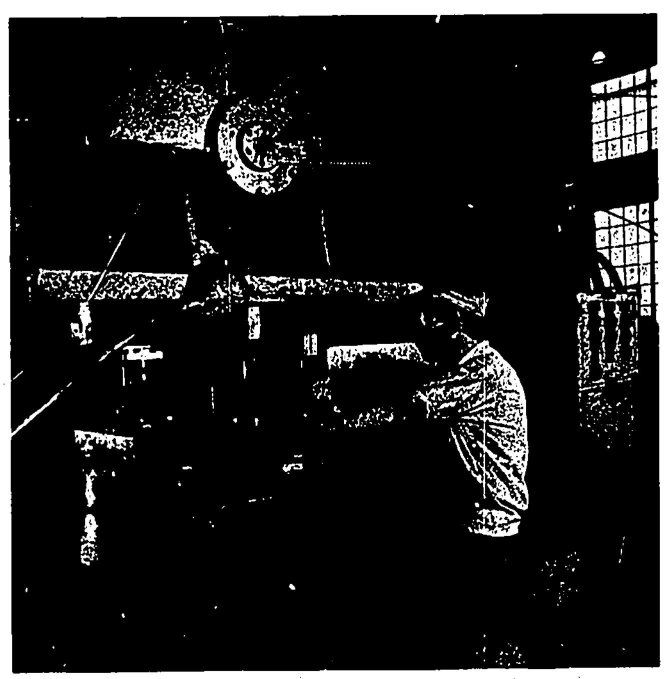


Fig. 54-6. A skilled worker aligns the dies of a punch press. It is his job to keep this press in perfect shape for continuous shearing processes.

Summary

Shearing is a process that cuts and gives shape to standard stock by the principle of mechanical advantage. It is less wasteful than chip removing.

Many kinds of standard stock are sheared. Some become parts to be processed further. Others become finished products that are ready to be packaged and shipped to the customer.

Shearing can take place at any time during the manufacture of a part or product. The kind of shearing tools and machines to be used depends on the kind of standard stock that is to be cut. Shearing is usually done on power presses by semiskilled or skilled workers. Many shearing jobs take place in the manufacture of any part or product.

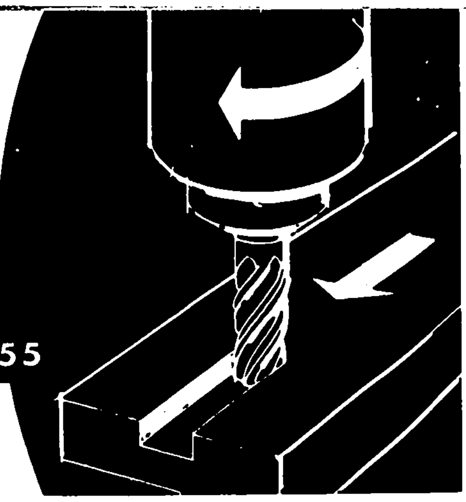
Terms to Know

shearing
chip removing
other processes
extruded
distribution processes
line of shear
straight-line shear
pressure
mechanical advantage
transmit
concentrated
high shearing strength
semiskilled worker
skilled worker
aligns
maintains

Think About It!

1. Explain the difference between the processes of shearing and chip removing.
2. Starting with standard stock textiles, identify the steps the cloth must go through to become the shirt you have on. Identify the steps in which shearing is done.

READING 55



Chip Removing

In this reading, you will learn more about a second way to separate standard stock: *chip removing,* Fig. 55-1. As you study this reading, you should try to *contrast* chip removing with shearing in order to understand better the differences between them.

Separation by Chip Removing

Chip removing takes off *excess* (extra) standard stock in the form of *chips* (small bits of the stock). The cutting tool may have one cutting edge or many of them. The chips are *removed* (taken off) by putting the *pressure* (force) of the cutting tool against the surface of the excess stock. *Sawing, drilling, sanding,* and *grinding* are common ways to remove chips from standard stock. Chips, shavings, sawdust, or other small bits are taken off in order to get the right shape or surface finish for the piece of standard stock.

There are many different ways to remove chips. Each way has a different name. Have you ever heard of *milling, shaping, reaming, honing,* or *lapping?* In principle, each of these ways to remove chips is the same. In each, a strong and hard cutting edge (or edges) cuts away excess standard stock.

Like shearing, chip removing cuts standard stock down to the right shapes and sizes. It is an *economical* (cheap, inexpensive) way to make a small number of parts of products. It can usually be done without buying or building costly tools or dies. Sometimes, chip removing is the most precise way to separate standard stock known to manufacturers. There are many *forms* (shapes) that can only be gotten by chip removing.

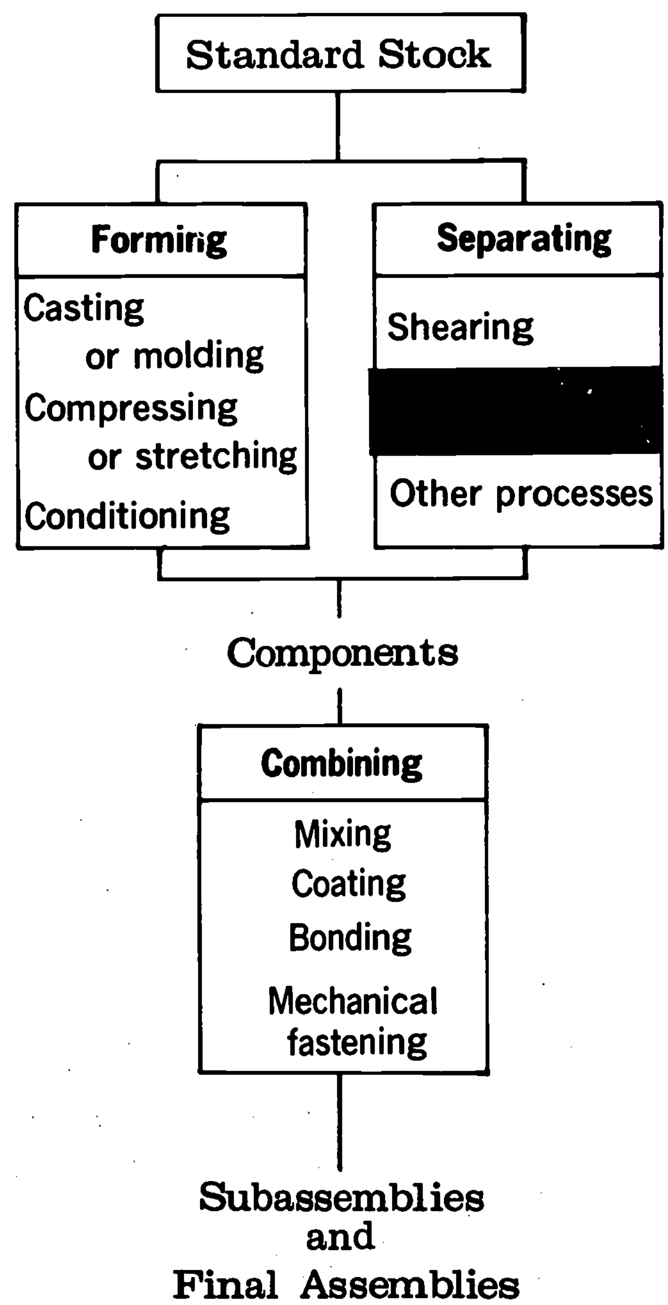


Fig. 55-1. Chip removing, in the shaded area above, is discussed in this reading.

Some of the tools used to remove chips have a single working edge or point. Others have many working edges.

Single-Edge Tools and Processes

There are many ways to remove chips that can be grouped together because they use *single-edge tools.* A single-edge tool is one with a single cutting edge that comes into contact with the stock being cut. The tool may be moved, or the standard stock piece may be moved. As the tool or the piece of stock moves, chips or bits fall away. The tool acts as a knife or a wedge as it takes off these small bits of excess stock. Tools of this kind are often called *single-point tools,* rather than single-edge tools.

Many kinds of single-edge tools and machines have been developed to remove chips of excess standard stock. The *chisel,* the *knife,* and the *scraper* are some of the simple hand tools that can be used to remove chips. The *lathe* (Fig. 55-2), the *plane,* and the *slotter* (Fig. 55-3) are some of the more *complex* (complicated) machines used to remove chips. The lathe is used to cut round parts down to the right size. It is one of the most important single-edge tools used to remove chips.

Single-edge tools and machines are used to make such round shapes as lamp bases and table legs. They are used to remove small bits of excess stock from flat surfaces. They are also used to cut *channels* (grooves) and to cut *irregular* (unusual) shapes.

Multiple-Edge Tools and Processes

There are ways to remove chips that can be grouped together because they use a tool with *multiple* (many) edges. The common saw is a *multiple-edge tool* that takes chips off as it cuts. As it cuts through wood, *sawdust* (small bits of wood) falls away.

There are times when you can use a multiple-edge tool, rather than a single-edge tool, to remove chips from standard stock.

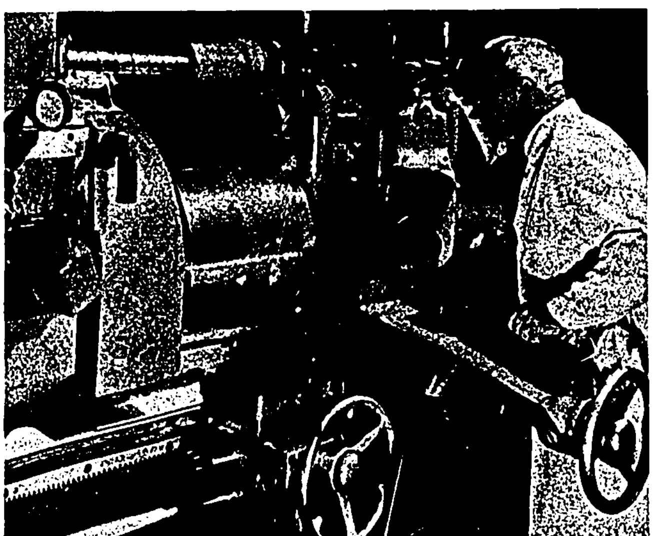


Fig. 55-2. The worker at this machine is using a lathe to cut a round casting down to the right size by removing chips from the workpiece. The lathe is the most common machine that uses a single-edge cutting tool to remove stock from a workpiece in the form of chips.

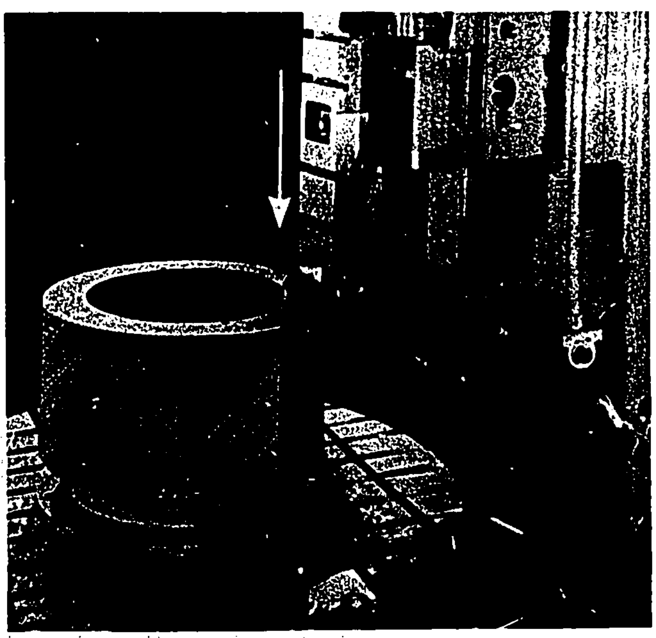


Fig. 55-3. A second machine which uses a single-edge cutting tool is a vertical cutting slotter. Here a sleeve for a marine engine is being machined to shape. The material is being removed in the form of chips.

With a multiple-edge tool you can take off more excess stock from a piece of standard stock than you can in the same amount of time with a single-edge tool. But the multiple-edge tool costs a great deal more than a single-edge tool designed to do the same job. *Twist drills* (Fig. 55-4), *milling machines* (Fig. 55-5), and *saws* (Fig. 55-6) are some of the common multiple-edge tools used to remove chips from standard stock.

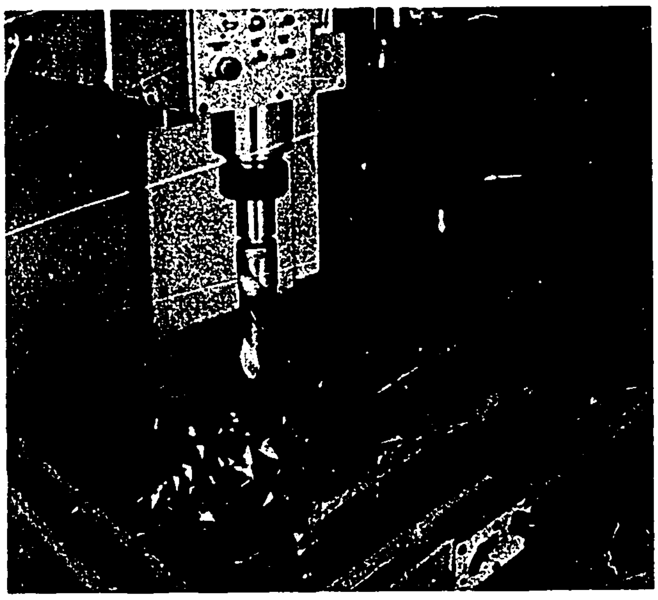


Fig. 55-4. A twist drill mounted in the jaws of a drill press is used to separate metal by removing chips. The twist drill is a multiple-edge cutting tool.

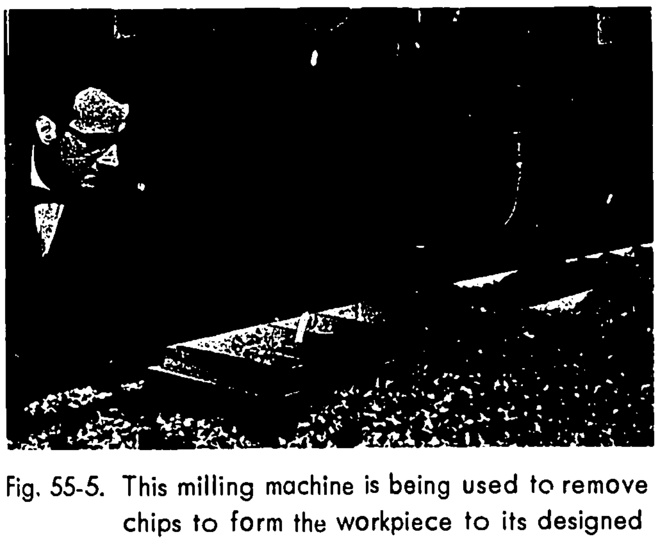


Fig. 55-5. This milling machine is being used to remove chips to form the workpiece to its designed shape.

Sometimes, these multiple-edge tools are called *multiple-point tools.* When you look at a saw, you first see the points of the teeth. When you look more closely, you see that each saw tooth has a cutting edge.

Garnet paper, emery cloth, and grinding wheels are called *abrasives* because they scrape excess stock away by rubbing their rough surfaces against the piece of standard stock. These abrasives are multiple-point cutting tools. For instance, each grain of abrasive on a piece of abrasive paper has sharp edges that can cut standard stock that is softer than the abrasive paper is.

The *grinding wheel* is a very important multiple-point cutting tool. It is set up in a machine with a motor that drives the wheel at high speeds. The wheel takes off very small bits of stock held against it. *Grinding* is usually done to hard stock that would be too tough to shape by any other way of chip removing, Fig. 55-7. A grinding wheel is hard and tough so that it can cut into hard standard stock.

Grinding is not used on pieces of soft standard stock because it is too slow a way to remove chips. There are other, faster ways to remove chips from soft stock. Grinding is usually used when close tolerances are needed, as they are in grinding piston rings. See Fig. 55-7. It is also used when rough metal surfaces must be smoothed. For instance, grinding is used to take rust off steel plates.

Two other abrasive ways to remove chips are *lapping* and *honing.* In each process, you can get a surface finish as close as one-half of a millionth of an inch.

Chip Salvage

Bits of excess standard stock in many different sizes are left over in all these chip removing processes. Some of these chips can be used to make important *by-products.* For instance, wood chips can be used to make fertilizer or mulch. Some chips are *salvaged* (saved) so that they can be used

over again. For instance, metal chips of steel and brass are salvaged and sold as scrap metal. Later they are melted down to be used again. Plastic chips are used again or sold for salvage.

Stages of Chip Removing

Chip removing can take place at many points in the *manufacturing cycle* (series of production processes). Some are done at plants that change raw materials into standard stock. For instance, logs are rough-sawed at the lumber mill before they are shipped to a fabricating plant.

Chip removing also takes place when standard stock is being made into parts. In each stage chip removing is done when the stock is needed in the manufacturing cycle.

Skills of Chip Removing

The skills needed to do chip removing jobs are as different as the jobs themselves. Some of them need only semiskilled workers to load automatic machines and to follow simple instructions, Fig. 55-8. But many chip removing jobs need highly skilled

Fig. 55-6. A heavy-duty production saw uses a multiple-edge cutting blade to cut wood down to the right size. When material is separated by sawing, a parting line is made and chips are removed. In this case, the chips come off in the form of sawdust.

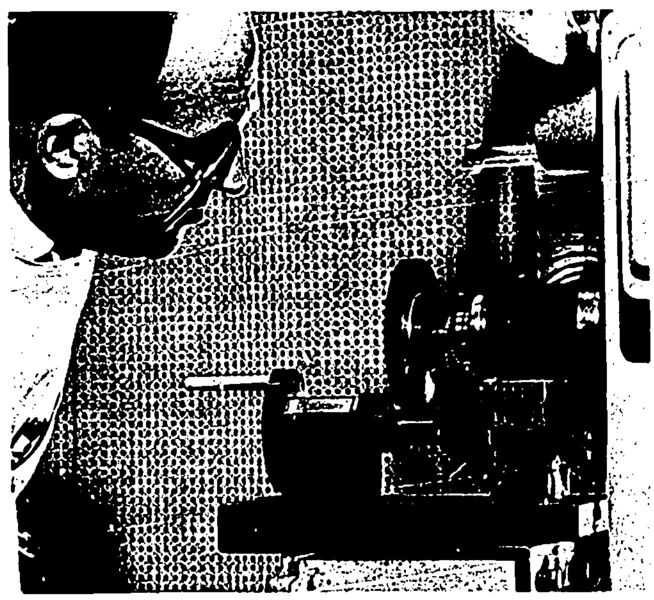


Fig. 55-7. A precision part for a machine is being ground to a very close tolerance by this surface grinder. This part cannot be machined in any other way because it has already been hardened to prevent wear.

Fig. 55-8. An automatic turret lathe is shown cutting many parts to identical size. The worker shown on the right does not need much skill to load this automatic machine and to follow simple instructions.

workers to do them. The worker at a lathe, grinder, milling machine, or *shaper* needs special skills. He must be able to set up his own jobs, run the machines, and check the final *dimensions* (sizes) of the parts as they come from the machines. Such a worker needs a lot of experience and training to do his job well.

Summary

Chip removing is a process that removes excess standard stock in the form of chips or small bits of stock. A cutting tool is used that may have one cutting edge or many of them.

There are two major ways to remove chips from standard stock. They are grouped according to the kind of tool used. They depend on whether the tool has one edge (single-edge tools) or many (multiple-edge tools). The cutting edge (or edges) must be harder and stronger than the standard stock that is being cut.

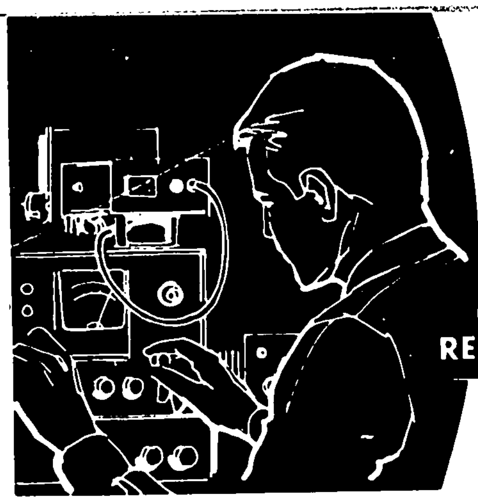
Terms to Know

chip removing
contrast
excess
chips
removed
pressure
sawing
drilling
sanding
grinding
milling
shaping
reaming
honing
lapping
economical
forms
single-edge tools
single-point tools
chisel
knife
scraper
lathe
plane
slotter
complex
channels
irregular
multiple
multiple-edge tool
sawdust
twist drills
milling machines
saws
multiple-point tools
abrasives
grinding wheel
grinding
by-products
salvaged
manufacturing cycle
shaper
dimensions

Think About It!

1. What tools or machines do you have around your home that are *single-edge* tools? *multiple-edge tools?*
2. Why is it more economical to use *chip removing* processes for making a small number of parts, rather than a large number of parts?

Separating by Other Processes



READING 56

In the last two readings, you have learned about two basic ways to separate standard stock. They are (1) *shearing*, and (2) *chip removing*. In this reading, you will learn about some other ways to separate standard stock, Fig. 56-1. They are sometimes called *other processes*, or *nontraditional techniques*. The ideas behind them are old, but some of the tools and their uses are very new.

There are four different ways to separate standard stock by these processes. They are (1) *thermal erosion*, (2) *chemical separating*, (3) *electrochemical separating*, and (4) *induced-fracture separating*.

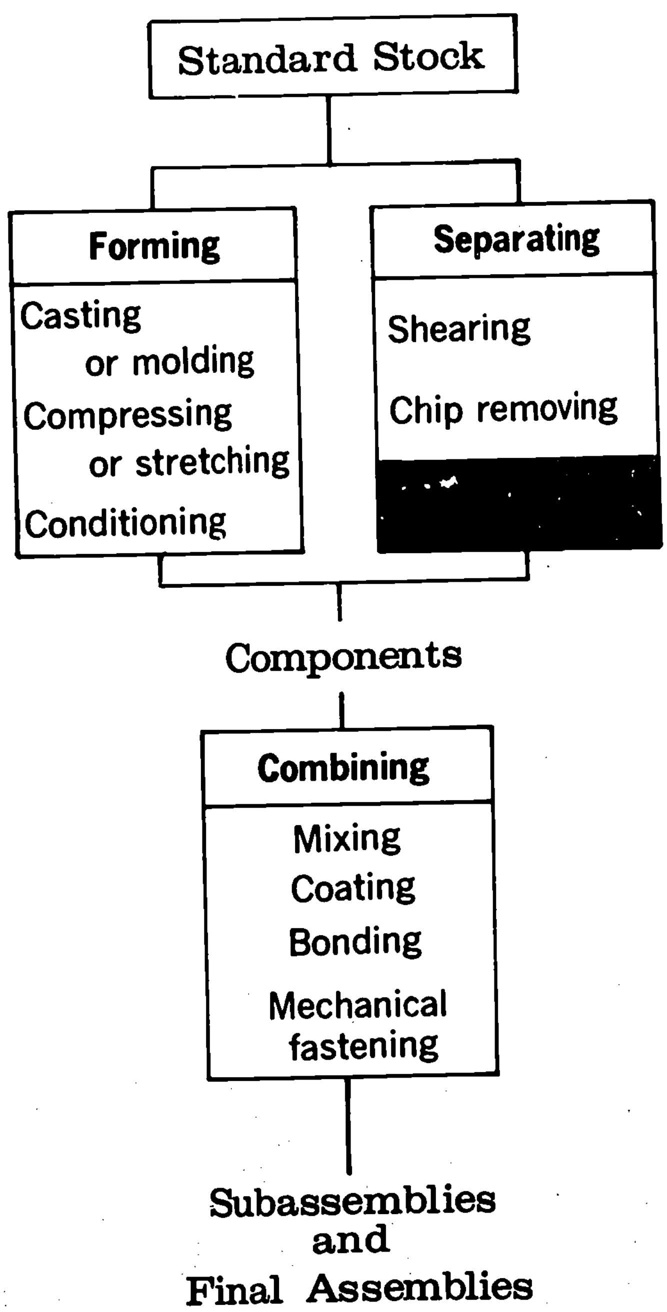


Fig. 56-1. Separating by other processes, in the shaded area above, is discussed in this reading.

Thermal Erosion

The word *erosion* comes from a Latin word that means to *gnaw or nibble away*. When heat energy is made to nibble away a small bit of standard stock, the process is called *thermal erosion*.

With a hand lens, you can make a beam of sunlight burn a hole through paper. The lens directs the sun's heat to one small spot on the paper. The *concentrated* (centered) energy of the beam of sunlight heats that spot on paper until it smolders and burns away. You have removed material, but the tool (the hand lens) did not touch the paper. This is what makes the process nontraditional. The traditional ways of shearing and chip removing use tools that touch the piece of standard stock.

In making metal products, one common kind of thermal erosion is *flame cutting*. Flame cutting starts by heating the metal at one spot, or along a line where the metal

is to be separated. When a tiny bit of the metal reaches its melting point, it either falls away or is blown away. This leaves a hole in the metal and *exposes* (lays open) more metal to the flame. The cutting keeps on until the metal along the cutting line is removed. The flame comes out of a tool that does not touch the metal. See Fig. 56-2.

An electric spark is another form of energy that can be used to separate standard stock. In manufacturing, the process is called *electrical discharge machining,* Fig. 56-3. This is often shortened to *E.D.M.*

For E.D.M. work, the piece of standard stock must be one that will *conduct* (let through) electric current. The tool is brought very close to the piece of stock being shaped, but never touches it. An electric spark then jumps the very narrow gap between the tool and the piece of stock. As it enters the piece of stock, the spark chips off a tiny bit of stock. A *dielectric fluid* (liquid that cannot conduct electric current) washes off the chips of excess stock. A new spark jumps the gap several thousand times a second. As these sparks chip off tiny bits of excess stock, they help to make the piece of standard stock into the right size and shape.

A *laser beam* can be made to *bore* (cut) a hole through solid stock, or to cut a piece of it in two. These are nontraditional bores and cuts, because the tool never touches the stock. *Laser* is a shortened form of Light Amplification by Stimulated Emission. A laser device *amplifies* (builds up) the strength of light. It concentrates a huge amount of light energy into one light beam.

With lenses and mirrors, the laser beam can be *focused* (centered) on a small spot on a piece of stock. There, some of the concentrated light energy is changed into heat energy. Some of the piece of stock *evaporates* (turns into steam or vapor) at that spot. If the beam is focused on a single spot, it can bore a hole at that spot. The material around the rim of the hole may melt or may change chemically. The heat energy does not spread far into the rest of the material.

If the laser beam is moved at the right speed, material along a cutting line will evaporate and the piece of stock will be cut in two. Very little material is wasted. Also,

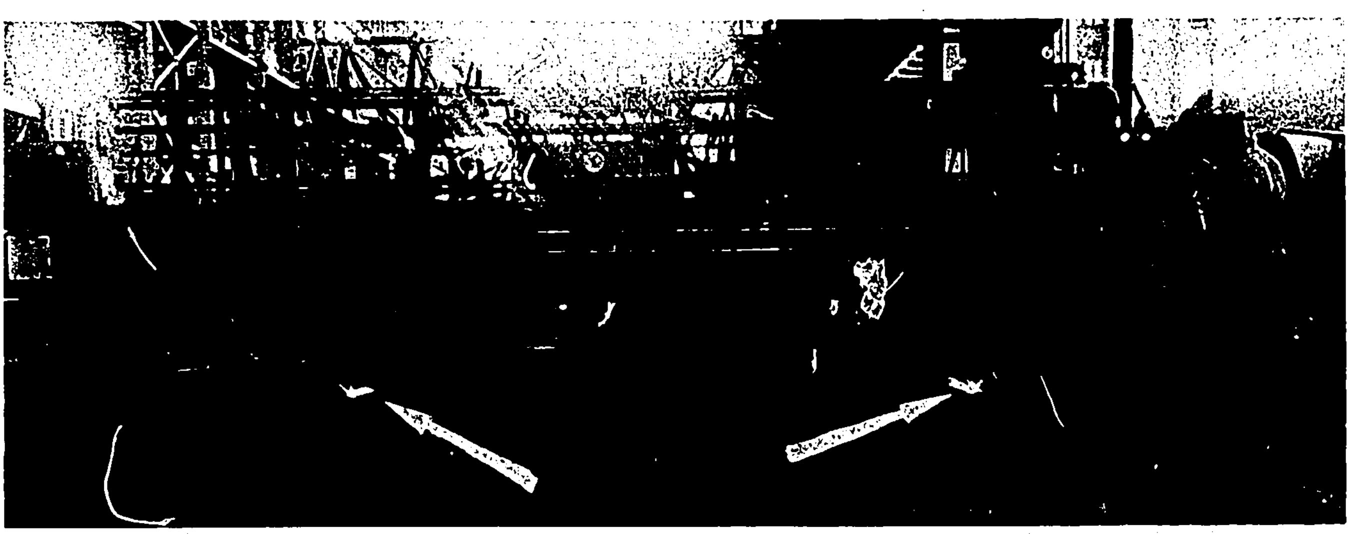


Fig. 56-2. Boiler plate is being cut in a thermal erosion process. The machine is a flame cutter (arrows point to two torches). The conveyor system holding these torches allows it to cut the plate very fast.

the laser beam does not wear out when it is used on very hard pieces of stock. No cutting edge touches the stock. These are all advantages. But the one big disadvantage of the laser beam technique is its high cost.

Fig. 56-3. This is an example of an electrical discharge machine. The worker is changing the distance between the tool and the workpiece for quick and easy removal of material.

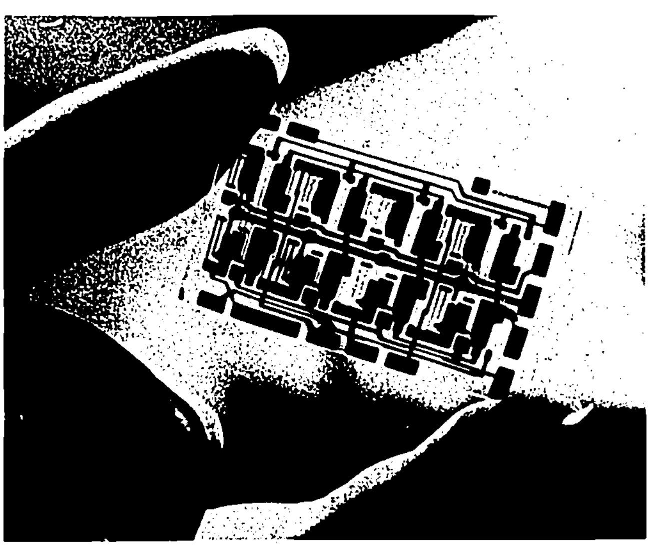


Fig. 56-4. This is an example of a printed circuit board after etching. The dark lines are strips of copper which remain on the front and back surfaces of the plastic.

Chemical Separating

A drop of strong acid on a metal surface will *etch* (eat into) the surface. Molecules of the acid will combine with molecules of the metal in a chemical reaction. The stronger the acid, the more molecules it will pull out of the metal.

It is easy to control etching. Many kinds of standard stock *resist* acids (cannot be etched by them). A coat of paint that resists acids will keep a metal from being etched. Such a coat of paint is called a *resist*. To control what parts of a metal surface will be etched, the whole surface is first coated with a resist. Then the resist is taken off the spots that are to be etched.

Etching is a very old and well-known process. For a long time, printing plates have been made by etching. Hot-rolled metals are cleaned by a process called *pickling*. This is a kind of etching. Metal parts are put into a pickling bath to get them ready for electroplating and other coating processes. Printing books or magazines from etched plates is not new, but printed circuits for radio or television sets were developed quite recently, Fig. 56-4. The original for a printed circuit is often a very large drawing. It is photographed by techniques that reduce it in size without making it any less precise. These new techniques are called *miniaturization*.

Electrochemical Separating

Suppose a piece of metal stock is connected to the positive terminal of a battery and a special tool is connected to the negative terminal. The electric current flowing between them can be used to separate standard stock. The current can pull molecules of metal away from the piece of stock in a controlled way. This process is done in a water solution that is *alkaline* (the opposite of acid). The tool is brought very close to the piece of stock, but never touches it. The water solution flows through a filter that strains out the metal molecules. Otherwise, they would build up on the tool.

In manufacturing, there are two ways to separate standard stock like this. One is called *electrochemical machining* (*E.C.M.*), Figs. 56-5 and 56-6. The other is called *electrochemical grinding* (*E.C.G.*). Each process has been developed recently. They are both useful for work that is very hard to do any other way. For instance, standard stock that is *fragile* (breaks easily) can be ground by an E.C.G. process.

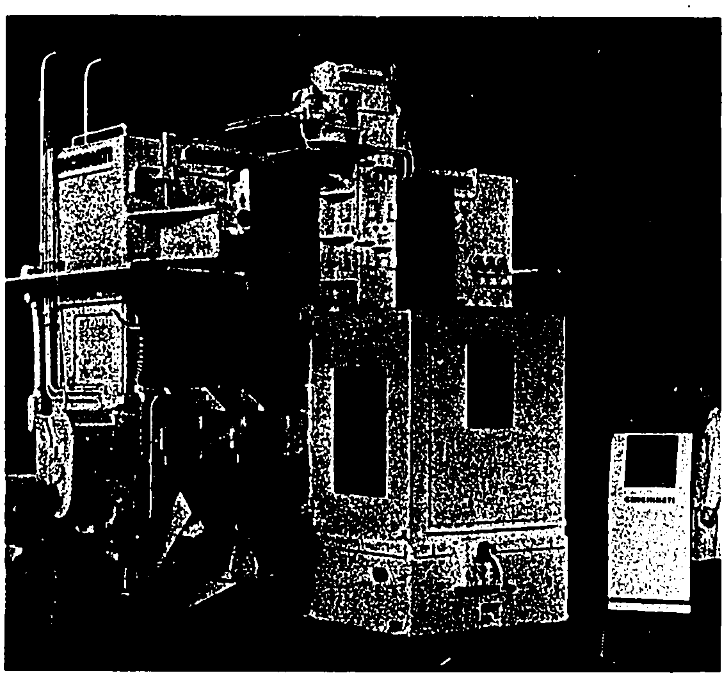


Fig. 56-5. This machine is one in which an electrochemical separating process takes place. The part (shown in Fig. 56-6) has been electrochemically machined.

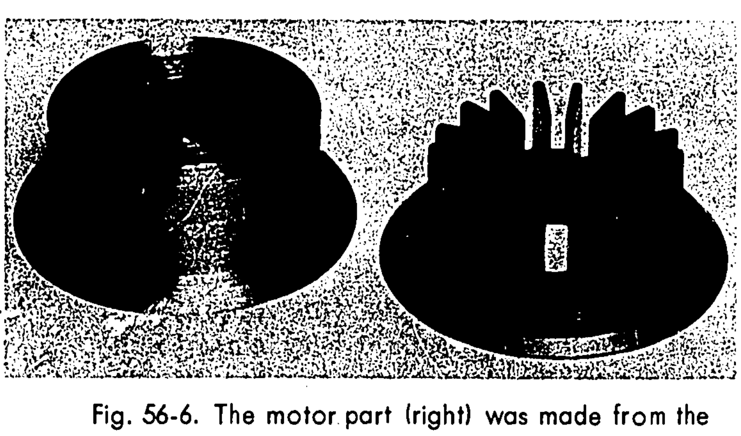


Fig. 56-6. The motor part (right) was made from the blank part (left) by electrochemical machining.

Induced-Fracture Separating

If you have ever split wood for kindling, you know what is meant by the term *splitting along the grain.* A straight-grained piece of white pine can be made to split along the grain into two straight pieces. If the grain curves around a knot in the wood, the piece will split along the curve. To make wooden shingles, the wood is split along its natural grain.

The American Indians who made flint arrowheads used a similar internal structure that nature had built into the flint. Flint will split easily in certain directions. With a simple chipping tool and a light blow from the hammer, the Indian could break a flake of flint free. But the angle of the tool and the direction of the hammer blow had to match the natural *axis* (direction) along which the flint would split.

When the Indian made an arrowhead, he *induced* (forced) the flint to *fracture* (break), Fig. 56-7. The physical force he needed for an induced fracture was less

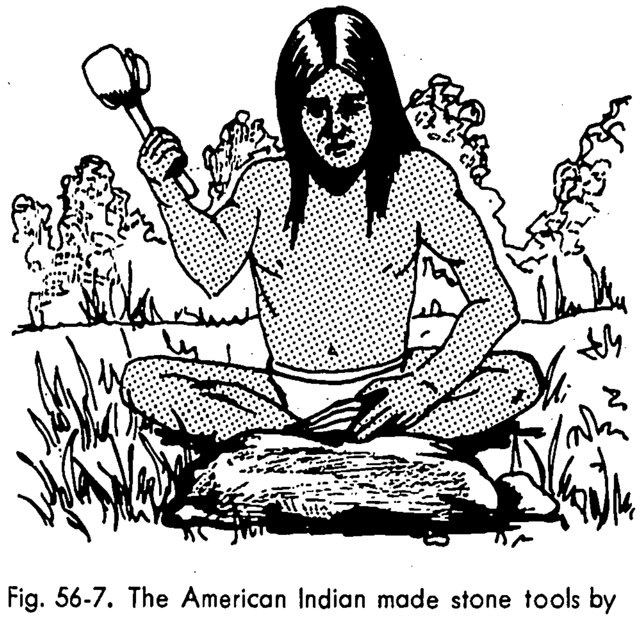


Fig. 56-7. The American Indian made stone tools by flaking chips from the stone. This process is called *induced-fracture separating*.

than the force he needed to shear or chip the flint away.

Some very hard minerals, like topaz, amethyst, and diamond, are made into jewels with many flat faces and straight edges. This can be done because in the crystal structure of these minerals, there are several natural *axes* (directions) for splitting or flaking the minerals.

In making metal parts, there are induced-fracture processes that use the grain of the metal to control the fracture. Figure 56-8 shows a connecting rod for a small gas engine. In order to *assemble* (combine, put together) this part with a crankshaft, it must be separated along the line shown in the sketch. The part is clamped in a fixture. A sharp blow in the right direction breaks the metal cleanly. After it has been assembled with the crankshaft, the two fractured pieces of the connecting rod are bolted together. They fit perfectly because no material was lost in the fracturing process.

Sometimes the easiest way to form several pieces of a part is to cast them all at the same time. The mold is shaped so that it forms grooves between each part of the casting. The casting is then hardened and taken out of the mold. It breaks easily along the grooved lines baked into it. The next time you snap a saltine cracker into two squares, notice the groove line. It was formed in the dough before it was baked.

In an induced-fracture process, the worker may use a natural axis line, along which the stock piece breaks easily. If there is no such axis line, he may make an axis line for a fracture by *scoring* the stock piece (scratching it with a hard tool). Glass can be scored to make a fracture line. If the scoring is done well, light pressure will break the glass cleanly along the scored line, Fig. 56-9. Other kinds of standard stock that must be scored before they can be separated by induced fracturing include stone, asphalt floor tile, ceramic tile, and plasterboard.

Processes of the Future

Man first separated materials very crudely. He used the strength of his own

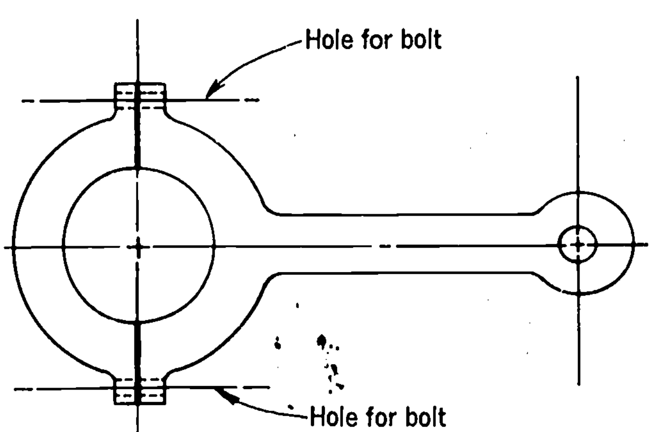


Fig. 56-8. In this front view of a connecting rod, the heavy line shows where the rod will be fractured. The dotted lines show where bolts will be put in after the connecting rod has been assembled with a crankshaft.

Fig. 56-9. Here, the glass is being scored to be later separated by induced fracture. A line across the glass made by this diamond-pointed tool will allow the glass to break along this line when pressure is put on it.

muscles to pull, push, jerk, or pound them. He depended entirely on his own muscle power to use the first chipping and shearing tools. Later, he invented many clever tools to separate materials. He also learned to *harness* (control and put to work) energy. He used this harnessed energy to run machines that did his shearing and chipping jobs.

It is now possible to harness the energy of heat, light, sound, electric current, and chemical reactions. Such harnessed energy is used in manufacturing to separate standard stock directly and in controlled ways. The techniques for using such energy become more clever and more imaginative every year. We can expect to find new ways to separate standard stock with a laser beam in the future. We can also expect to lower the high cost of this technique. We can expect to find new ways to separate standard stock. These new ways will be based on scientific principles now being tested in research labs, or on principles that technologists will find in future research. In theory, every form of energy can be used to separate standard stock in any form: solids, liquids, gases, and other states of matter that science is now learning about.

Summary

There are several ways to separate standard stock that are nontraditional. They are (1) thermal erosion, (2) chemical separating, (3) electrochemical separating, and (4) induced-fracture separating.

Thermal erosion is one way to separate some kinds of standard stock. There are several kinds of thermal erosion techniques. Flame cutting separates by direct use of heat. Electrical discharge machining is done with electric sparks that heat tiny bits of standard stock until they fall away as chips. Laser beams can be used to separate stock. The laser beam changes concentrated light energy into heat. This heat can then be focused on a single spot on a piece of standard stock in order to bore a hole through it. Or it can be focused along a cutting line in order to cut a piece of stock in two.

Another way to separate standard stock uses chemical reactions. Etching is a very important way to separate stock chemically. Printing plates are made by etching. Etching is used to make printed circuits for radio and television sets.

Electrochemical separating is used to grind and machine standard stock to the right size and shape. E.C.M. and E.C.G. processes take place in an alkaline water solution that conducts electric current. The current pulls molecules of metal away from the stock piece to help make it the right size and shape.

In an induced-fracture process, standard stock is separated by forcing it to break in a controlled way. The way it breaks depends on the natural grain or the crystal structure of the standard stock piece. Some kinds of standard stock must be scored before they can be fractured.

In the future, we can expect improved techniques and lower costs for these improvements. Thus there will be more uses for them in the manufacturing of the future. We can also expect new techniques to be developed, either from principles now being tested or from ones that have not yet been found.

Terms to Know

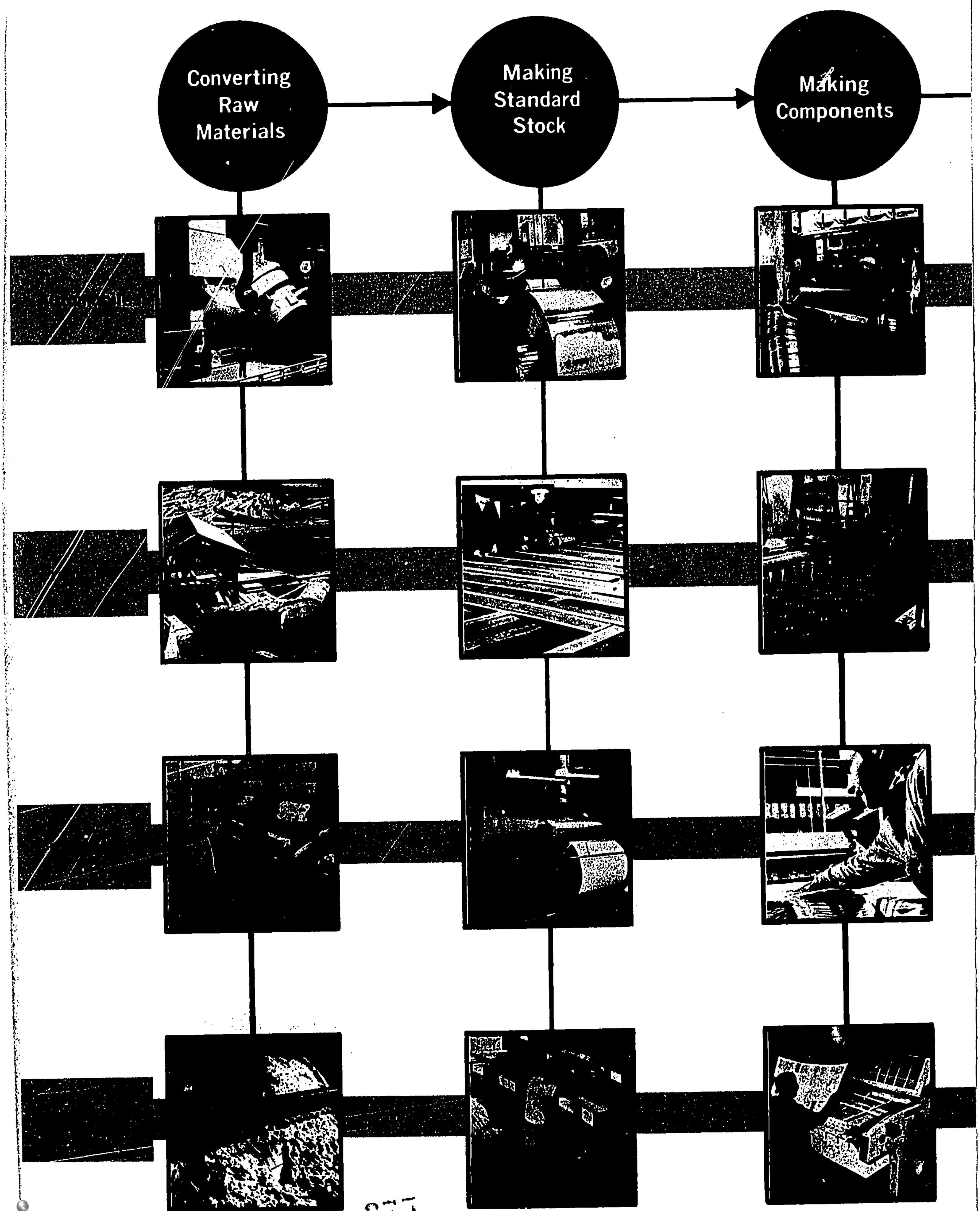
shearing
chip removing
other processes (non-traditional techniques)
thermal erosion
chemical separating
electrochemical separating
induced-fracture separating
erosion
concentrated
flame cutting
amplifies
focused
evaporates
etch
resist
pickling
miniaturization
alkaline
electrochemical machining (E.C.M.)
electrochemical grinding (E.C.G.)

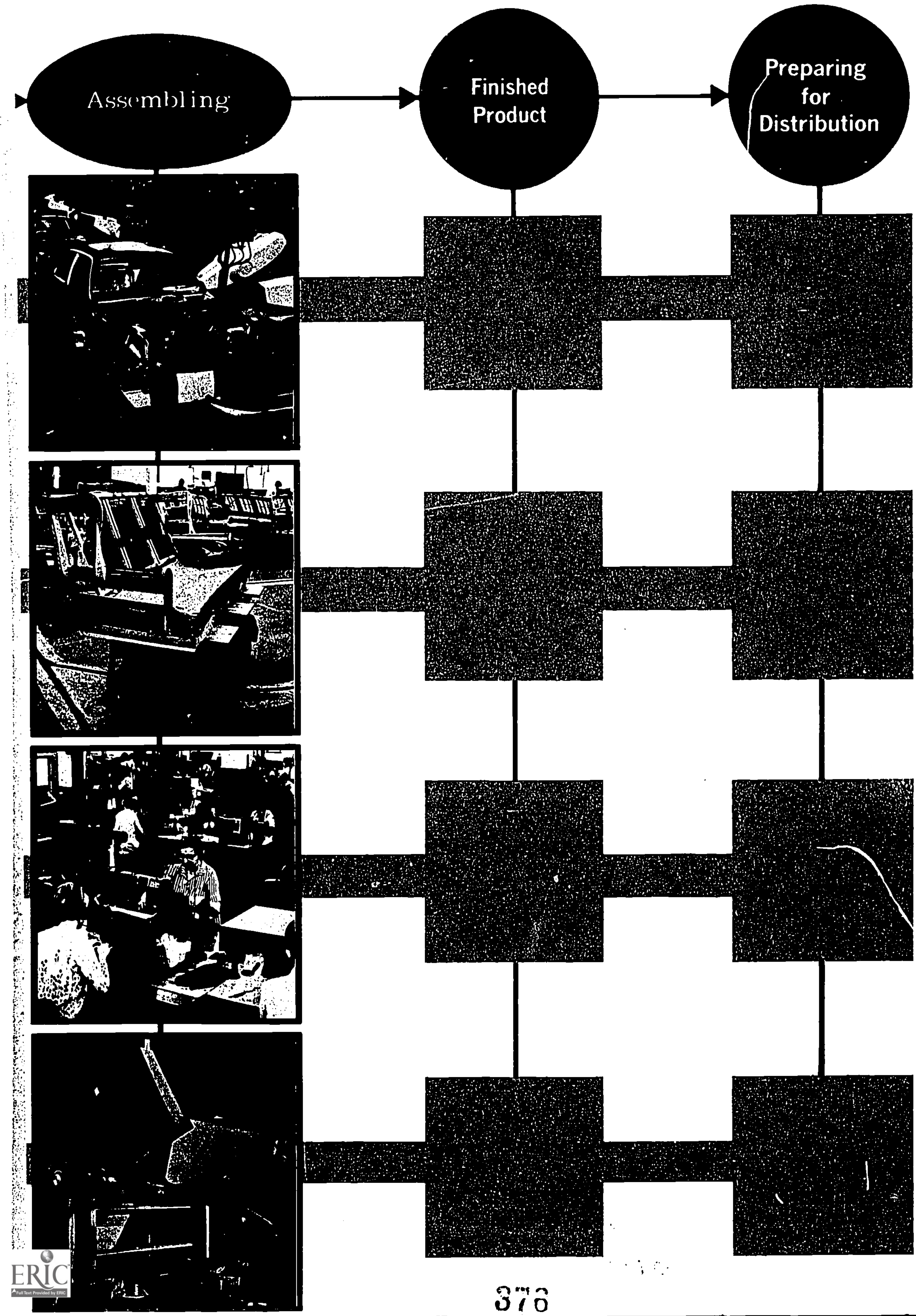
exposes
electrical discharge machining (E.D.M.)
conduct
dielectric fluid
laser beam
bore
assemble

fragile
splitting along the grain
axis
induced
fracture
scoring
axes
harness

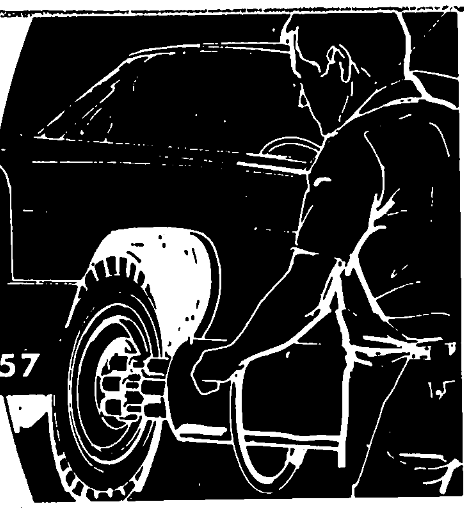
Think About It!

1. How have advances in nontraditional separating processes helped in miniaturization?
2. Explain the differences between thermal erosion, chemical separating, electrochemical separating, and induced-fracture separating.


Converting Raw Materials
Making Standard Stock
Making Components


Assembling
Finished Product
Preparing for Distribution

READING 57



Making Assemblies or Finished Products

In the last nine readings, you have learned about ways to change standard stock into *components* (parts) or simple one-piece products. In this reading, you will begin to learn about some of the ways to *assemble* (combine, join) parts into more *complex* (complicated) products, Fig. 57-1.

Parts are joined to make *subassemblies* and *assemblies.* An assembly may be a simple two-part or three-part product. It may be a more complex product. You will learn a little about four ways to join parts. They are (1) *mixing,* (2) *coating,* (3) *bonding,* and (4) *mechanical fastening.*

Subassembly and Assembly

In manufacturing, the term *assembly* can refer to the *process* that joins parts together. It can also refer to the *product* made by joining these parts. Sometimes the process joins only two parts. Other times, hundreds and even thousands of parts are joined to make a complex product like an airplane.

Let's take an example. Suppose that a key has been *stamped* (sheared) from a sheet of standard steel stock. If the key is not to *corrode* (slowly wear away), it must be *plated* (coated) with some metal like nickel or chromium. Is the plating process called *assembly?* Not in a plating shop! But two parts (the key blank and the plating material) have been joined. The words *combine* and *assemble* mean very much the same. Both words mean to join. In this reading, *assemble* will be used in a very general way to mean *join,* or *put together.*

Suppose a key blank is to be cut and joined to an assembled *multiple-component*

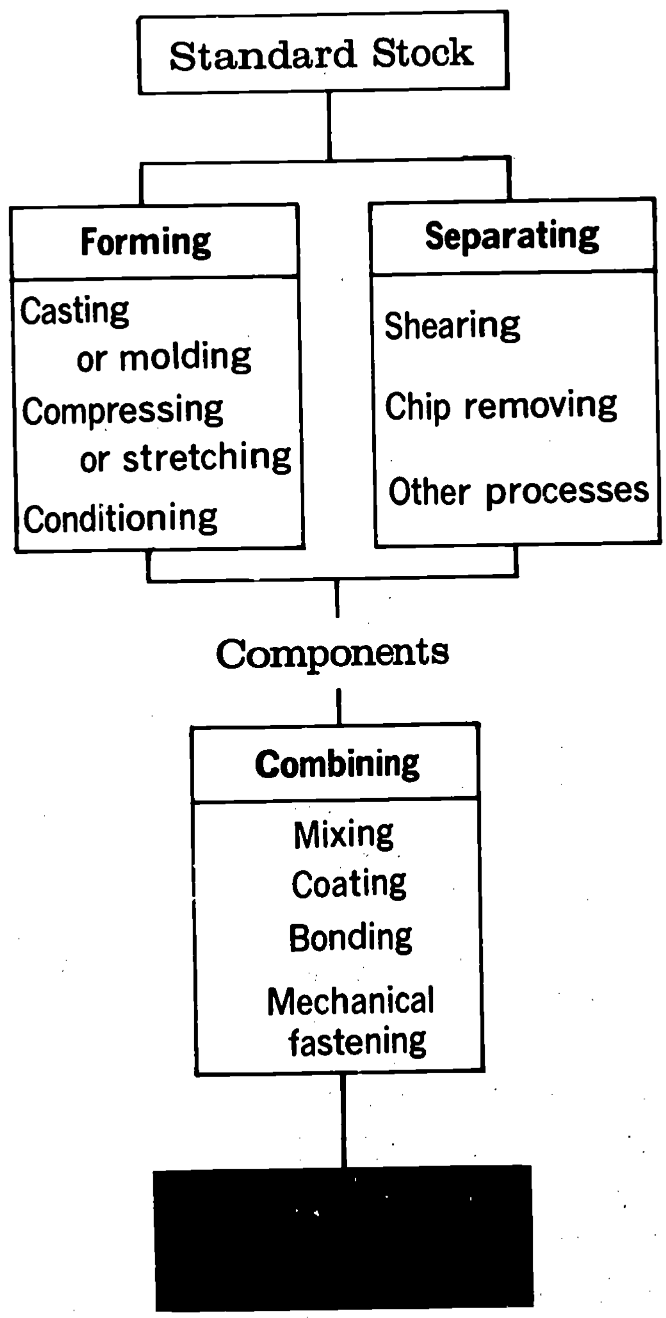


Fig. 57-1. Subassemblies and final assemblies, in the shaded area above, are discussed in this reading.

lock (one that has many parts). Now you have two *subassemblies:* the key and the lock. Together, they may be thought of as an *assembly.*

Now suppose that the lock, with its key, is sold to a cabinetmaker. He will put this lock in the door of one of the cabinets he manufactures. Thus the final assembled product from the lock plant becomes a subassembly in the plant of the cabinetmaker.

When is a set of combined parts called a *subassembly,* and when is it called an *assembly?* It all depends on (1) who is working with it, (2) where that person is in the *manufacturing cycle* (series of production processes), and (3) how the combined parts are finally used.

With a large complex product, this can get very complicated. To make a car, for instance, an auto plant must buy parts and assembled products from nearly 800 companies. The auto plant itself must make many more parts and subassemblies. The total number of parts, both those made in the plant and those bought by the plant, runs into the thousands. These must first be joined into simple and complex subassemblies. Then all of these are assembled into the finished product—a car. For instance, the engine subassembly can be made up of the following smaller subassemblies: air cleaner, oil filter, oil pump, distributor, carburetor, and alternator, Fig. 57-2.

These two products, the car and the lock with its key, show the different ways the terms *assembly* and *subassembly* are used. See Figs. 57-3 and 57-4.

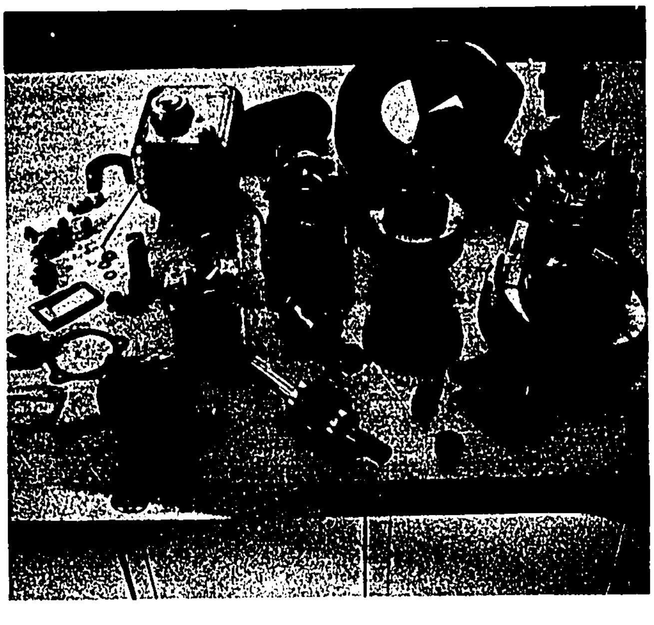


Fig. 57-2. A small gasoline engine has several subassemblies. How many subassemblies are shown in this picture?

Fig. 57-3. These women are part of an assembly line where electrical measuring instruments are made.

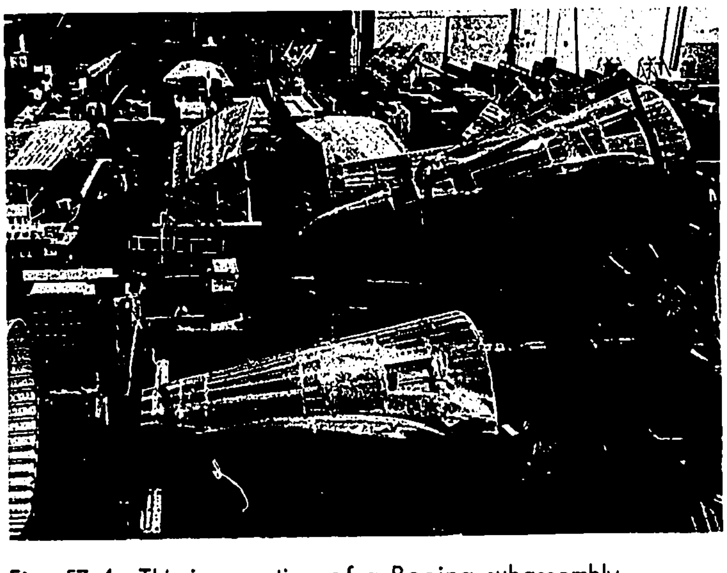


Fig. 57-4. This is a section of a Boeing subassembly line at the Northrop Aviation Corporation.

To add to the confusion, many people use the term *component* not only to mean a single part made from standard stock, but also to mean the same thing as a *subassembly*. For instance, a transistor is really a subassembly of several components, but it is often called a *component* of a radio.

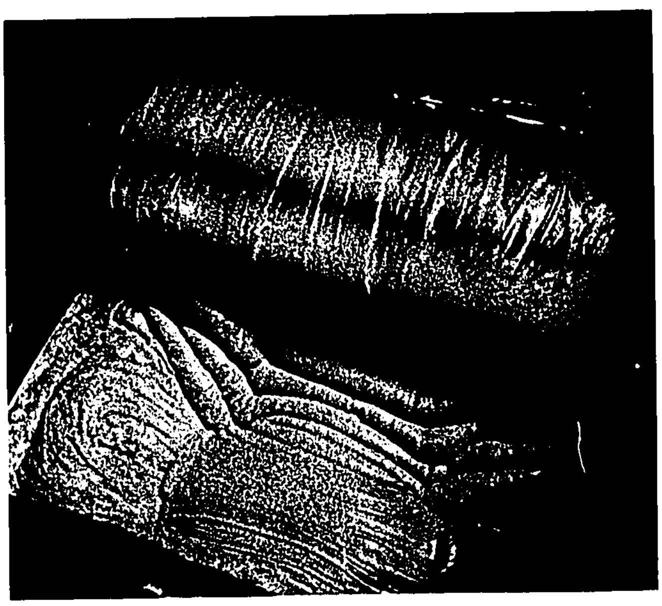


Fig. 57-5. Mixing is a combining process very common in the food industries. Here, candy is being poured from a large mixer into a hopper.

Combining Practices

There are four major ways to combine parts. They are (1) *mixing*, (2) *coating*, (3) *bonding*, and (4) *mechanical fastening*. Depending on the kind of parts and the product made from them, any one (or several combined) may be used in the manufacture of the product.

Mixing combines gases, liquids, and solids. It is used a great deal in chemical, petroleum, and food plants, Fig. 57-5. It is used in many other manufacturing plants as well.

Coating covers one piece of standard stock with a *coat* (layer) of another. Coating is usually done to parts or products for three reasons. The first is to improve their looks. The second is to protect them from wearing out or wearing away, Fig. 57-6. The third is to keep dirt and other matter from getting inside them or sticking to them.

Bonding joins two or more parts in more or less *permanent* (long-lasting) ways. Bonding can melt standard parts until they *fuse* (run together). Welding is an example, Figs. 57-7 and 57-8. Bonding can also use *adhesives*, like glue or bonding cement, to join parts together.

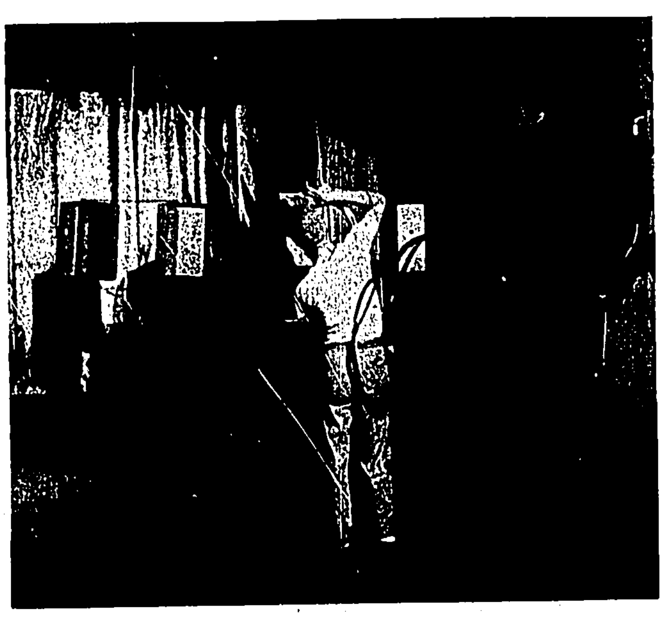


Fig. 57-6. A c ating of paint is often necessary to protect the product from wearing away or wearing out.

Fig. 57-7. The parts of an auger are being welded together. Welding is a bonding process.

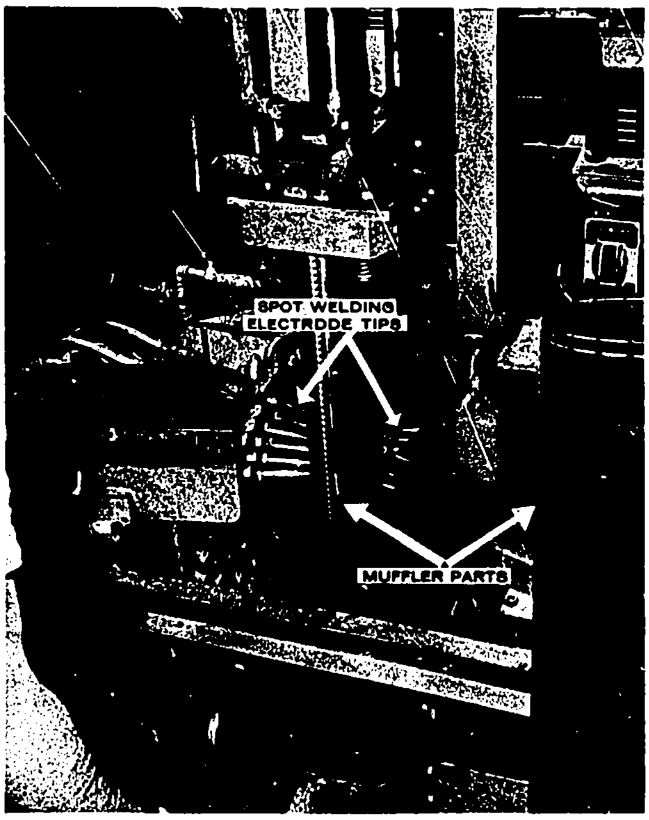


Fig. 57-8. The internal parts of a muffler are being welded to the outer shell. This is a bonding process.

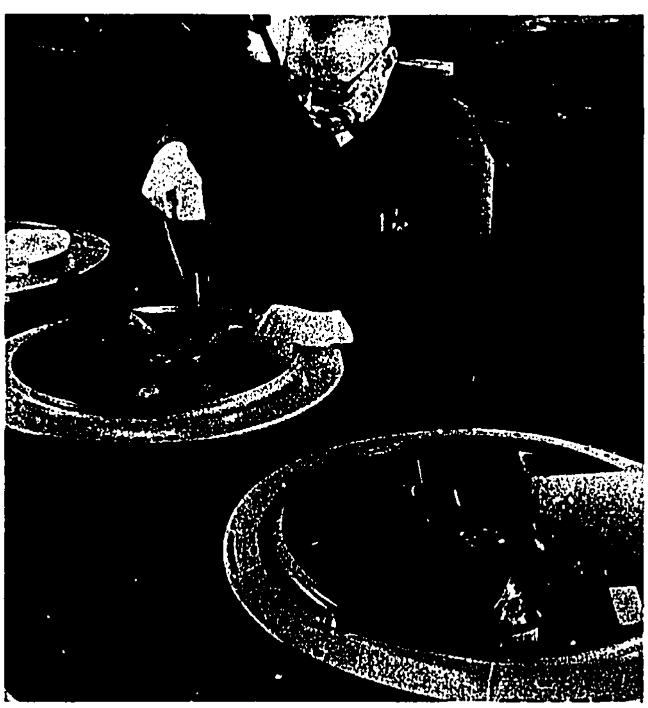


Fig. 57-9. Mechanical fastening joins parts with such fasteners as nuts and bolts.

Mechanical fastening joins parts with such fasteners as staples, nails, rope, thread, bolts and nuts, screws, rivets, or pins, Fig. 57-9. Fasteners like these often allow the parts or subassemblies to be taken apart to be fixed or to make changes in them.

Summary

Some products are made in one piece from standard stock. Most other products, though, are made by combining parts that may be gases, liquids, or solids. This process of joining parts (components) is called assembling.

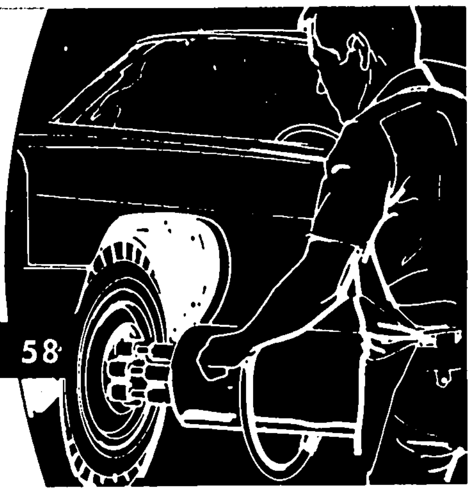
The next several readings will explain in detail four ways to combine parts. They are (1) mixing, (2) coating, (3) bonding, and (4) mechanical fastening.

Terms to Know

components
assemble
complex
subassemblies
assemblies
mixing
coating
bonding
mechanical fastening
assembly
process
product
stamped
corrode
plated
combine
join
put together
multiple-component manufacturing cycle
coat
permanent
fuse
adhesives

Think About It!

1. Name some of the products around your home and identify which parts were *assemblies* in one stage of their manufacture but *subassemblies* in others.
2. What products can you name in your classroom that have been combined by *mixing?* by *coating?* by *bonding?* by *mechanical fastening?*



READING 58

Combining Components

Most products are made from several *components* (parts), Fig. 58-1. Whether the parts are solid, liquid, or gas, they must be combined. There are four major ways to combine parts. They are (1) *mixing*, (2) *coating*, (3) *bonding*, and (4) *mechanical fastening*, Fig. 58-2.

Some products are simple one-piece products like plastic plates, Fig. 58-3. Some products are simple liquids like milk, or simple gases like oxygen. Liquids and gases must be put into containers. Then these containers must be closed. Often no other *combining process* is needed.

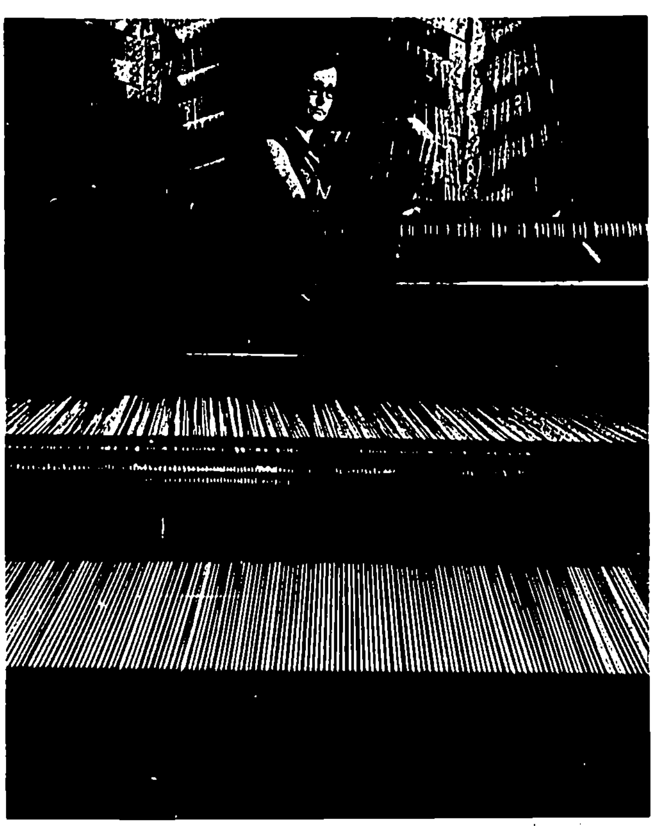


Fig. 58-1. Hundreds of polyester cords are combined with other materials to form tire fabric.

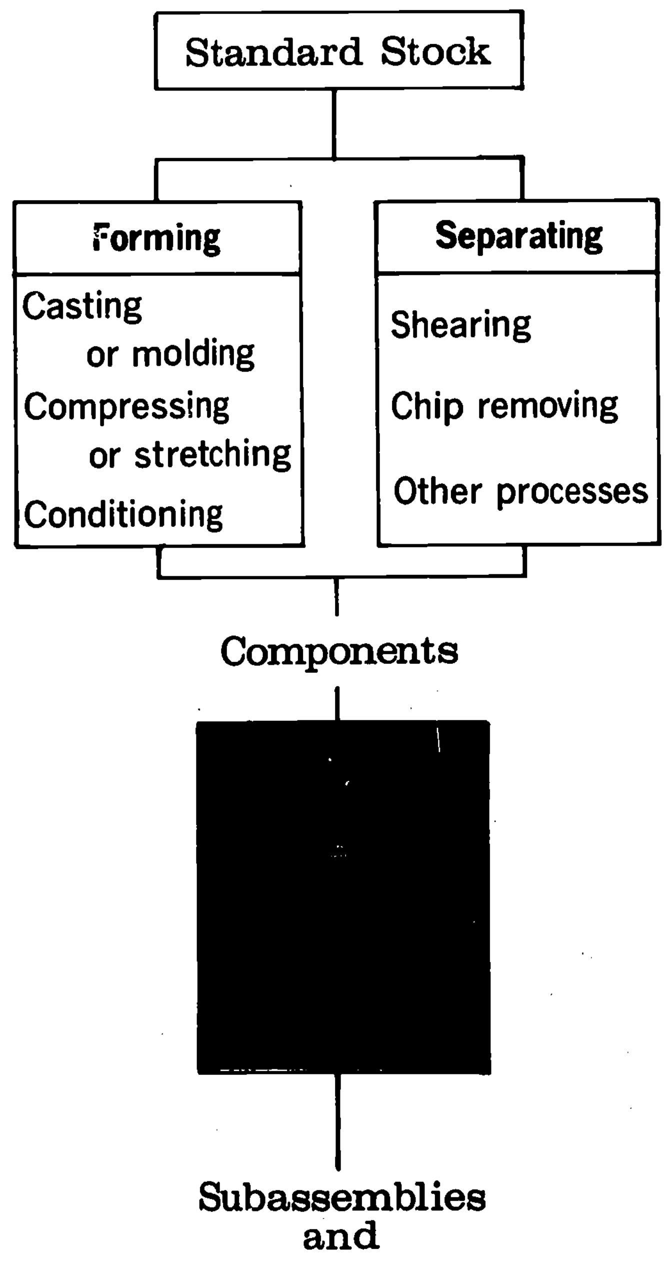


Fig. 58-2. Combining, in the shaded area above, is discussed in this reading.

Mixing

Mixing is one way to combine components. Mixing moves particles of solids, liquids, or gases around until each *ingredient* (element) has been spread evenly throughout the whole mixture.

Mixing is also called *compounding*, especially in the manufacture of drugs. To a chemist, the word *mixture* does not mean the same as the word *compound*. To a manufacturer, both words mean the same thing. They may refer to any combination of gases, liquids, and solids.

Mixing is done most often with such nonmetallic organic and inorganic components as cement, wood pulp (Fig. 58-4), gasoline, and bread and cookie dough.

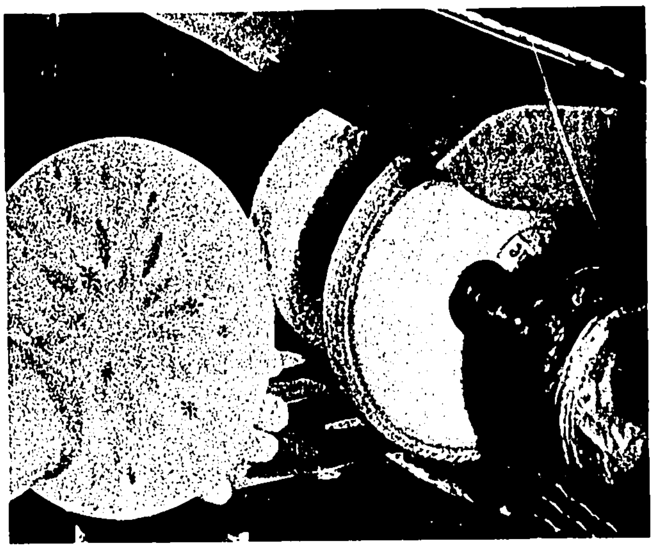


Fig. 58-3. This plastic plate is an example of a one-piece product that combines parts before forming and separating are done.

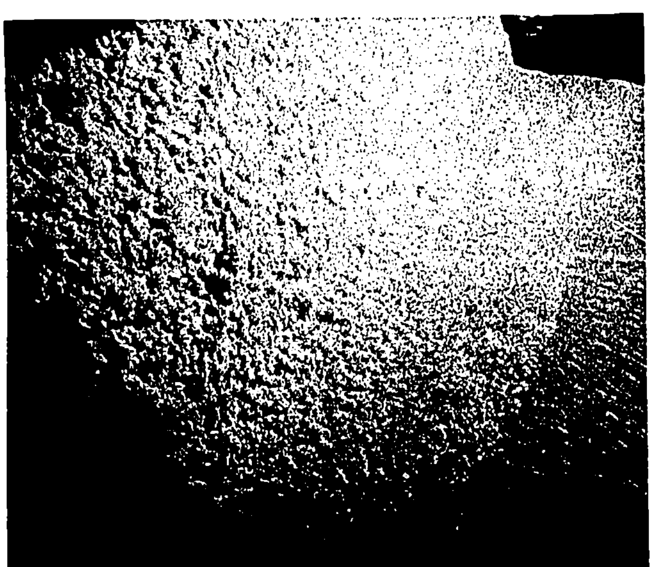


Fig. 58-4. This is a mixing process in which chemicals are mixed with wood pulp to process it into paper.

Coating

Coating is another way to combine parts. Many parts or assemblies get what is commonly called a *coat of paint*. Since real paint is hardly ever used in manufacturing today, the word *paint* usually refers to varnish, lacquer, or enamel. This group of paints should be called *organic coatings*, because they have *organic chemicals* (those that come from once-living plants or animals) in them.

Ink on paper is a coating. In printing, a coat of ink is put over the surface of a line of type. This is done so that the letters and other marks can be printed on a piece of paper.

Galvanizing and *electroplating* are two ways to coat metals. Each process *deposits* (lays down) a layer of one metal onto the surface of another metal, Fig. 58-5.

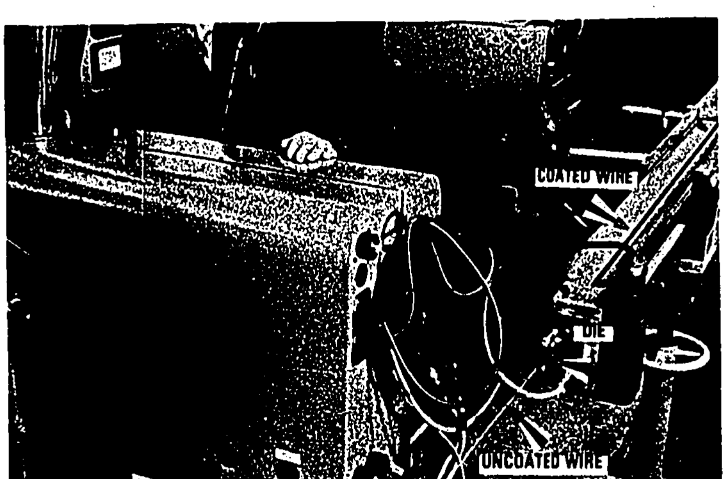


Fig. 58-5. This worker is coating wire. The uncoated, heated wire is pulled through a coating die, and is coated so that it will not wear away.

A *vitreous* coating is a thin layer of glass. Vitreous coatings give a very hard, strong, long-lasting finish to metals. They are often used on sinks, bathtubs, stoves, and refrigerators. This thin layer of glass is also called *porcelain enamel.* It is made from *inorganic materials* (those that come from minerals and other nonliving sources). When a vitreous coating is placed on ceramic dishes and pottery it is called a *glaze.*

Coatings are put on for many reasons. They are put on to *decorate* (look good to the eye). They are put on to *preserve* (reduce wear and tear). They are put on to make the product easy to clean. They are put on to seal *pores* (tiny openings) in standard stock and get it ready for another coating. They are put on to reduce noise by cutting down on *vibrations* (shocks). They are put on to control light, as when glass is coated with aluminum to make mirrors. They are put on to control heat. These are only a few of the many reasons why coatings are put on components.

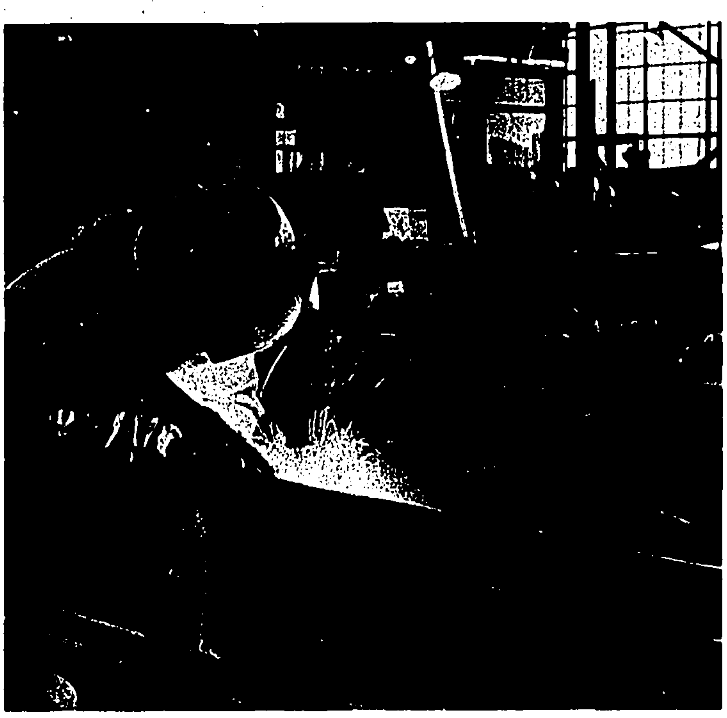


Fig. 58-6. As a fusion-bonding process, welding is widely used in constructing nuclear submarines. This welder is welding a frame for a submarine.

Bonding

There are two major ways to bond parts. They are:

1. *fusion bonding,* and
2. *adhesive bonding.*

Two parts *fuse* when their surfaces run or mix together. *Welding* is a fusion process, Fig. 58-6. If glue, paste, or cement is used to bond two parts, this is called *adhesive bonding.* Usually, bonded parts are not meant to come apart. They are permanently joined.

In welding, two metal parts are heated and held together until they fuse. The temperature must usually rise above the melting points of both metal parts. A piece of wire, made of the same metal, is also melted to fill any gaps between the touching surfaces of the two parts. Molecules of metal from both parts and from the wire all run together. Thus the whole assembly cools as one solid piece.

Brazing is very much like welding. The wire used in brazing, though, is made of a metal that melts at a lower temperature than the metal parts. When the wire is heated, it melts into liquid form, but the

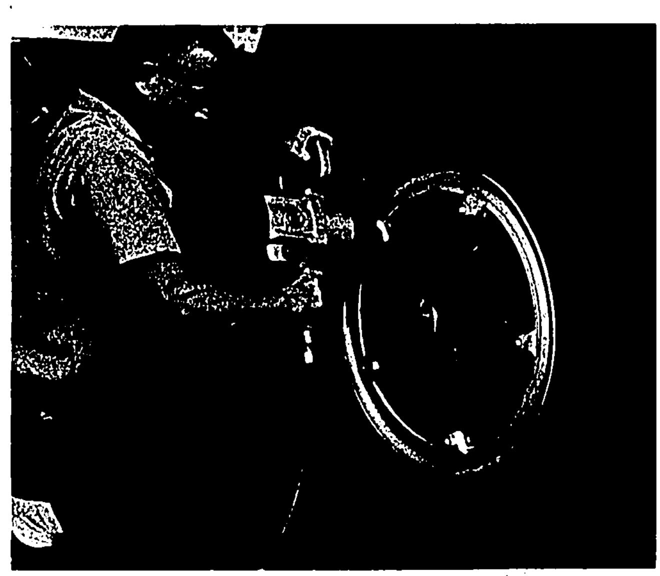


Fig. 58-7. Two of the most common fasteners used in mechanical fastening are nuts and bolts. Here nuts and bolts are used to hold a tire in place.

metal parts only soften a little. Molecules of metal from the brazing wire mix in with the surface molecules of each metal part.

If brazing is done at such low temperatures that the metal parts do not soften at all, then the wire metal does not mix with the parts. In this case, brazing is thought of as a special kind of adhesive bonding.

Until recent years, welding and brazing were the only techniques that could be counted on to bond metal parts. There were several kinds of glues and cements, but some of them did not stick well to metal. Others lost their strength as they aged or as water got into them. Now there are new kinds of adhesives, chemically quite different from glue, that can be used to bond metal parts.

Mechanical Fastening

Mechanical fastening is probably the oldest and most widely used way to join parts. Perhaps it started when primitive man used a jungle vine to bind a stone and a stick together in order to make a tool.

Modern mechanical fasteners include thread, twine, wire, rope, screws, rivets, cotter pins, keys, spring clips, nails, staples, tacks, nuts and bolts (Fig. 58-7), and many different kinds of retainer rings. There are so many kinds of fasteners that it would be impossible to describe them all in this reading. In a later reading, you will learn more about the most widely used kinds of mechanical fasteners.

Each mechanical fastener links together two or more parts. Often the fastener can be unfastened. This allows the parts to be taken apart to be fixed or to be changed. Unlike a bonded assembly, these assemblies are not *permanent* (long-lasting).

Summary

Parts are joined or combined to make complex products. There are four major ways to combine parts. They are (1) mixing, (2) coating, (3) bonding, and (4) mechanical fastening.

Mixing moves particles of solids, liquids, or gases around until each ingredient is spread evenly throughout the mixture. Coating puts a layer of one kind of standard stock on top of another to decorate, preserve, or seal it. Bonding puts something between the joined parts to hold them together. There are two major ways to bond parts. They are (1) fusion bonding, and (2) adhesive bonding. Mechanical fastening links two or more parts together. Fasteners allow the parts to be taken apart to fix them or to change them.

Terms to Know

components
mixing
coating
bonding
mechanical fastening
combining process
ingredient
compounding
mixture
compound
coat of paint
paint
organic coatings
organic chemicals
galvanizing
electroplating
deposits
vitreous
porcelain enamel
inorganic materials
glaze
decorate
preserve
pores
vibrations
fusion bonding
adhesive bonding
fuse
welding
brazing
permanent

Think About It!

1. Read the ingredient label on a food product in a liquid form, a solid form, and a powdered form, and list the ingredients that were mixed together to produce each product.
2. Look at a product in your home, a bed for example, and identify which parts were coated, bonded, and mechanically fastened.

READING 59

Mixing

Mixing is one of the four major ways to combine standard stock. The gases, liquids, or solids that go into a mixture are its *ingredients*. In the mixing process, the bits or particles of each ingredient are spread evenly through the mixture. In this reading, you will learn how mixing is done and how it is used in manufacturing, Fig. 59-1.

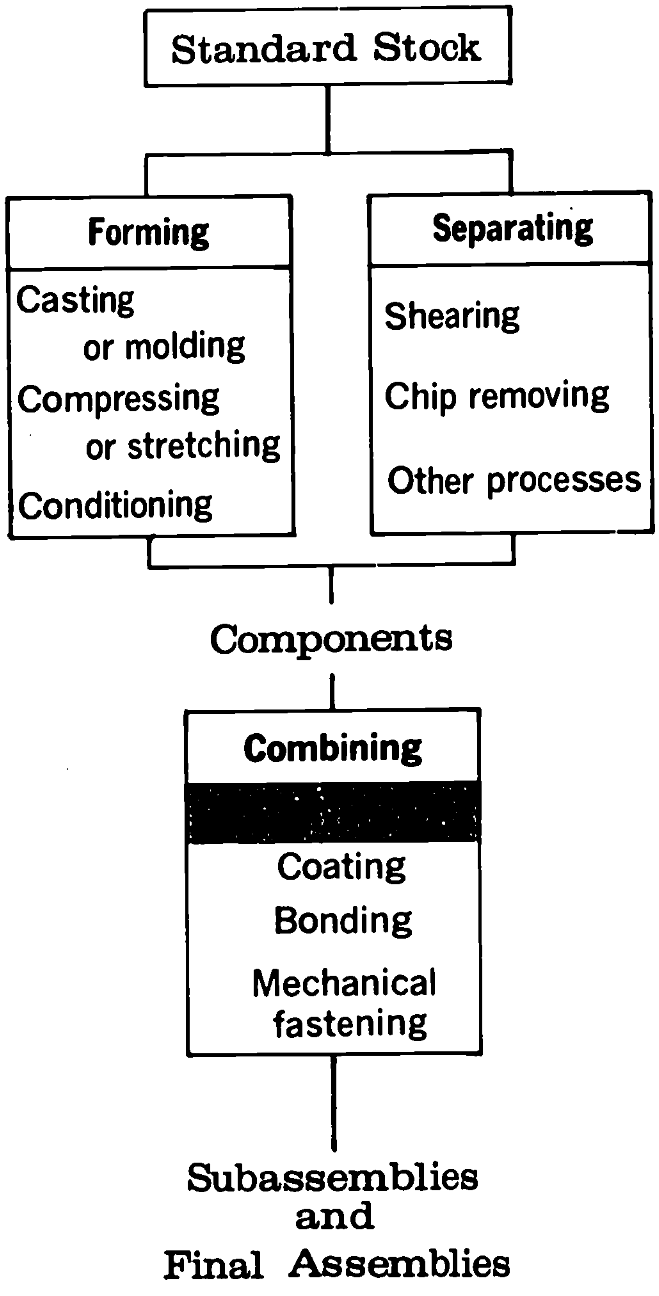


Fig. 59-1. Mixing, in the shaded area above, is discussed in this reading.

Mixing Two Solids

The first step in making a cake is to sift together several dry solid ingredients. These include flour, baking powder, and sugar. Each one is in the form of a *powder* (fine grains) before the mixing starts.

A *manual* (hand) flour sifter is a simple tool. It stirs and shakes powdered dry ingredients in a container and then lets them fall out through a screen. In the food industry, the dry solid ingredients for cakes are mixed in large batches by automatic power machines.

Dry ingredients for many other foods are also mixed. A can of ground coffee may include coffee beans of two or three kinds. Seasoning salt may have ten different herbs and spices mixed with common table salt.

The mixing of dry ingredients is important in manufacturing drugs. A headache pill may have three or four ingredients. The amount of each one must be carefully controlled. Each one is weighed on a very precise scale before the mixing starts. The mixing machines are designed so that no lumps or large grains are left unmixed.

Portland cement is a mixture of dry solids of a very different kind, Fig. 59-2. Its ingredients are clay and crushed powdered

limestone. A batch of cement is quite bulky and heavy. The machines that mix it must be very large and strong.

When dry solids are mixed, the mixture is not usually any different from the ingredients that went into it. If there is supposed to be a chemical change in the ingredients, they must be heated, mixed with a liquid, or processed in some other way.

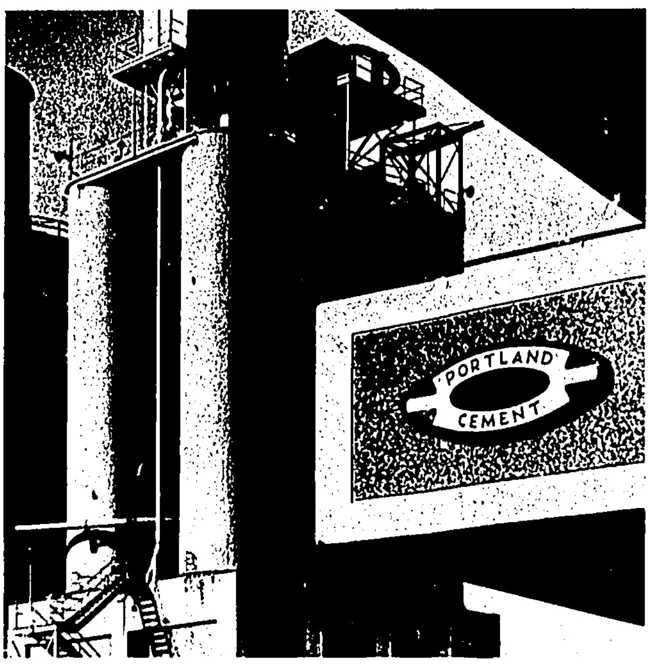


Fig. 59-2. Portland cement is a mixture of dry solids. Pictured here is part of a manufacturing plant where cement is made.

Practices of Agitating Solids

Several kinds of tools and machines are used to mix dry solids. Also, the ingredients usually stay inside a container during the whole mixing process. There are four ways to *agitate* (mix) dry solids. They are (1) *stirring,* (2) *tumbling,* (3) *mulling,* and (4) *fluidizing.*

Stirring. A simple hand tool like a shovel or a spoon can be used to stir small batches of dry ingredients. Larger batches are usually stirred by power machines, Fig. 59-3.

Tumbling. A load of socks in a clothes dryer gets thoroughly mixed if the dryer drum *rotates* (turns) or rolls. This kind of mixing is called *tumbling.* The container is often shaped like a drum or a barrel. In is partly filled with the ingredients in the right amounts, and then closed. It is then rolled or turned to mix the ingredients. You may have seen a concrete mixer mounted on a truck. It mixes the concrete by tumbling.

There are many ways to use tumbling in manufacturing, Fig. 59-4. One of these is

Fig. 59-3. This worker is mixing the basic ingredients for a photographic emulsion by stirring.

Fig. 59-4. Boron is being added to a mixture and tumbled in a blender to make sure the mixture is homogeneous (the same throughout).

called *barrel rolling*. In another, the containers have high-speed propellers spinning inside them while they roll or turn. In still another, the containers have baffle plates on their inside walls. Ingredients bounce off these plates in many directions as the drum rolls or turns.

Mulling. Ingredients in *granular* (very small grains) form are placed in a circular tub. Power-driven wheels run freely over the ingredients. The moving wheels produce a sideways rubbing force that helps to mix the ingredients, Fig. 59-5.

Fluidizing. Ingredients in powder form can be mixed by passing air currents through them, Fig. 59-6. As the air flows through the containers of powdered ingredients, it moves them around and mixes them. Since air is a *fluid* (something that flows), this way of mixing is called *fluidizing*.

Mixing Two Liquids

Gasoline and most other petroleum products are mixtures of several liquids. Oil companies mix gasoline with other liquids called *additives* to make a fuel that works well in a car engine. Motor oils are mixtures of oils and liquid *detergents* (cleaners). See Fig. 59-7.

Liquid mixtures are often used in making chemicals and drugs. Liquids are measured either by weight or by *volume* (space taken up) before they are mixed. Measuring by volume is often called *metering*.

Fig. 59-6. Technicians are experimenting with a fluidizing machine for new reactor concept studies.

Fig. 59-5. Mulling is a mixing process. Here, sand is being mulled to condition sand in a foundry.

Fig. 59-7. In making turpentine, several kinds of liquids are mixed in these tanks.

Some liquids, like molasses, pour very slowly at room temperature. Others, like water, pour easily. Most people use the words *thick* and *thin* to talk about the way a liquid pours. It is more precise to say that a slow-pouring liquid is very *viscous.* You could also say that it has a *high viscosity.* Molasses is very viscous. It has a high viscosity. Water is not very viscous. *It has a low viscosity.* It is not very easy to mix two viscous liquids. It is not very easy to mix two liquids like water and molasses, because one (water) is not very viscous at all, while the other (molasses) is very viscous.

Practices of Agitating Liquids

Liquids that mix easily are often just poured together. The energy of their molecules does the mixing. Other liquids must be shaken together to get them to mix.

Small amounts of liquids are often mixed by hand with a paddle or a spoon. Motor-driven propellers, paddles, or beaters are used for large batches, Fig. 59-8. They are also used to make the mixing easier. Pumps can be used to move liquids around until they are mixed. In *pneumatic agitation,* air is bubbled through the liquids to make them mix. Shakers and vibrators are used to mix small amounts of liquids. For instance, you make a milkshake in a blender. *Ultrasonic vibration* (shocks from high-frequency sound waves) is sometimes used to mix liquids.

Mixing a Solid and a Liquid

Salt, sugar, and many other solids will *dissolve* (melt) in water or other liquids. You cannot see salt or sugar after it dissolves in water. But you can *recover* it (get it back) if you make all the water *evaporate* (turn into steam or water vapor). Dissolving is a physical change that is *reversible,* because you can get back what you started with. When solids dissolve in liquids, the mixture is called a *solution.*

You have probably seen that sugar dissolves faster in hot tea than in iced tea. In manufacturing, when an ingredient is to be dissolved in a liquid, the temperature of the *solvent* (liquid) is carefully controlled.

Solids do not always dissolve in liquids. Some can only be *suspended* in the liquid (held in small particles spread evenly throughout the liquid). Concrete is made by

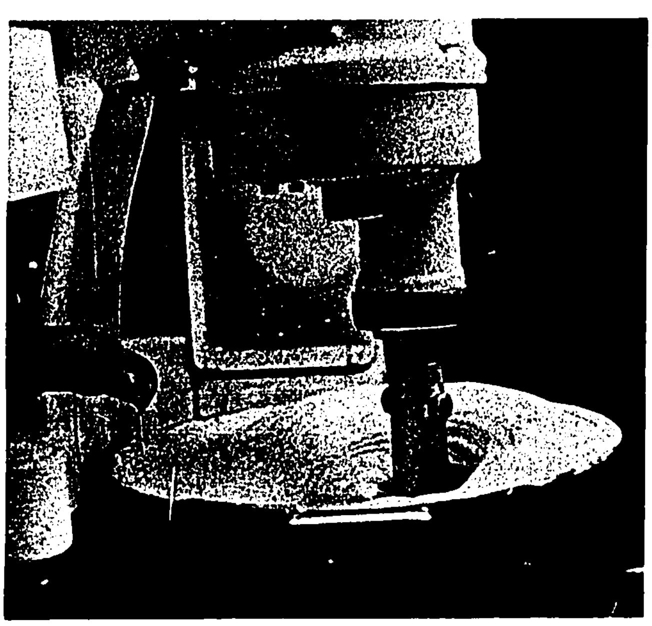


Fig. 59-8. Syrup and whipped egg whites are being mixed in a huge bowl by agitation.

Fig. 59-9. When a liquid is mixed with a solid, the solid does not always dissolve. In making concrete, cement and water react chemically to form a new and different product.

mixing cement, sand, gravel, and water. At first, the mixture is very viscous, with the sand and gravel spread evenly through it. The cement and water react chemically to form a new and different substance, Fig. 59-9. As the concrete hardens, the sand and gravel are trapped in the hardened mass. This process is *not* reversible. The water and dry cement cannot be recovered by heating.

Many chemical reactions take place when solid and liquid ingredients are mixed. When bread dough is *kneaded* (worked and pressed into a lump with the hands), a chemical reaction in the dough lets loose thousands of tiny gas bubbles. It is these gas bubbles that make the dough *rise*. See Fig. 59-10. More chemical reactions take place when the dough is baked. After a loaf of bread is baked, it is not just dough with a little of the water removed. It is a new substance, different from the raw dough mixture. Its ingredients cannot be recovered by just adding water to it.

Paint is made by mixing finely powdered ingredients with liquid ones. A chemical reaction between the paint mixture and the oxygen in the air is what makes the paint dry into a new substance. To make paint, it takes special knowledge of chemistry and special machines for mixing.

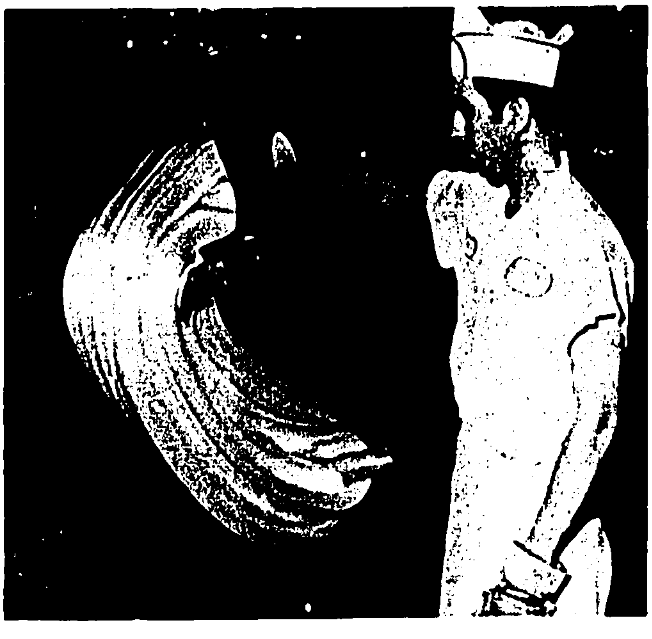


Fig. 59-10. A mechanical kneading machine is pulling a batch of viscous candy. It mixes in air for sheen, and spreads the flavor and color evenly throughout the mixture.

Mixing Gases

Gas mixtures are widely used in manufacturing. They also have many uses outside manufacturing.

Compressed hydrogen is one example of a gas mixture. Because hydrogen is *unstable* (can explode), it is sometimes mixed with nitrogen. The mixture of these two gases is more stable and thus safer to handle.

Usually, gases that are to be mixed are *metered* (measured by volume). This is done to make sure that the mixture will have the right *proportions* (fractions) of each gas.

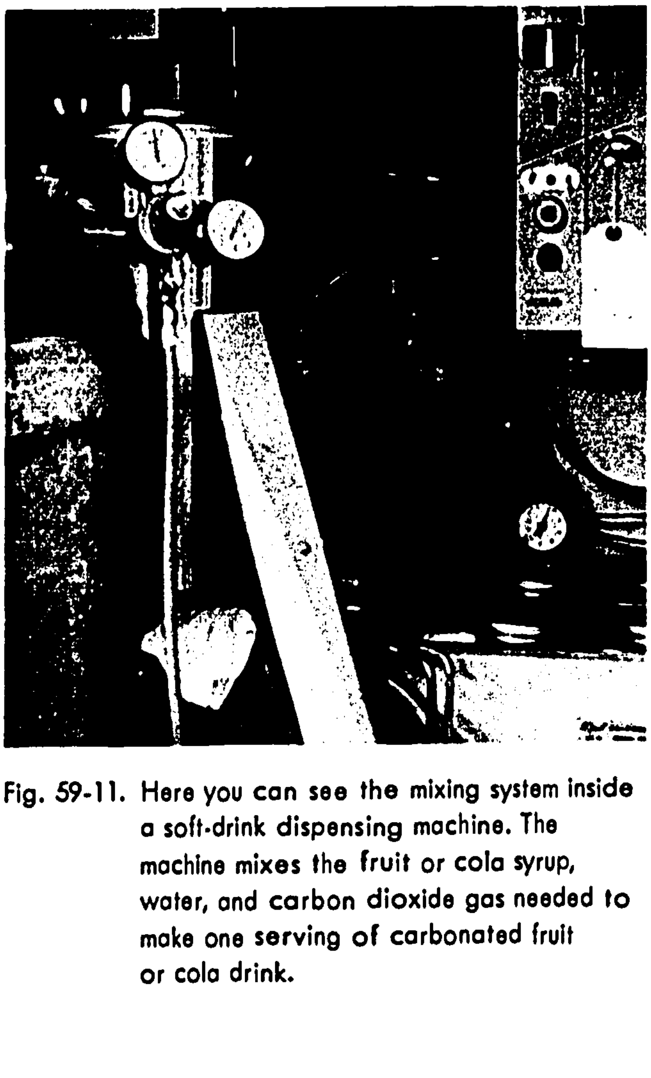


Fig. 59-11. Here you can see the mixing system inside a soft-drink dispensing machine. The machine mixes the fruit or cola syrup, water, and carbon dioxide gas needed to make one serving of carbonated fruit or cola drink.

Then the gases are passed into a container through a common mixing valve.

The molecules of a gas move very fast. They move much faster than the molecules of a liquid or a solid. When two gases are to be mixed, nothing special is needed. If they are put togther in a closed container, they will mix freely and thoroughly.

Mixing a Gas and a Liquid

Some products are mixtures of gases and liquids. There is a mixture of hydrochloric acid, water, and free chlorine gas in one of the common laundry bleaches. Chlorine gas is bubbled through a very *dilute* (weakened) solution of hydrochloric acid until the chlorine gas gets to the right strength.

Some soft drinks are *carbonated.* Carbon dioxide gas under pressure is made to dissolve in the liquid, Fig. 59-11. If you uncap a bottle of cola or carbonated fruit drink, you will see the gas form into bubbles and rise to the surface.

Fig. 59-12. An electron microprobe is used by these research technicians for analyzing chemical compounds.

Mixing and Compounding

The term *compound* has different meanings to different people. To a chemist, mixing two ingredients does *not always* produce a compound. If each ingredient keeps its own *properties* (qualities), the chemist calls the product a *mixture.* On the other hand, if a chemical reaction takes place between the two ingredients, a new substance with new properties has been made. The chemist calls this new product a *compound.* He may call the process *compounding,* or *forming a compound.* See Fig. 59-12.

When a druggist mixes two medicines to fill a prescription, he often says that he is *compounding* the prescription. He says this even if the two medicines do not chemically react. Keep in mind, then, that the terms *compound* and *compounding* have more than one meaning, depending upon to whom you are talking.

Summary

Mixing is a basic way of combining. The components of a mixture are called ingredients. In industry, processes and tools or machines have been developed to mix gases, liquids, and solid dry ingredients.

If a chemical reaction takes place when ingredients are mixed, then the mixture will have new and different properties. If there is no chemical reaction, then the properties of the mixture will be like those of its ingredients.

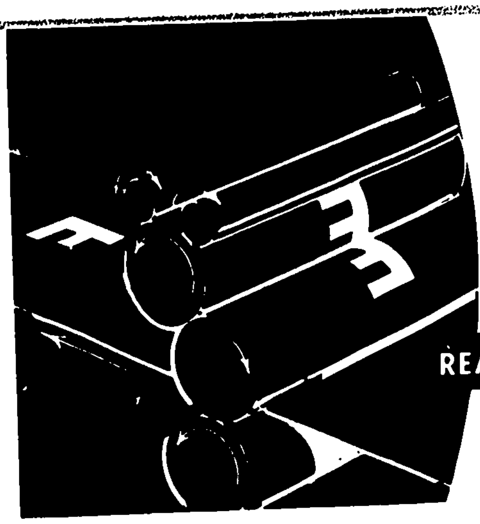
In industry, mixtures are often called compounds. But in chemistry, the terms *compound* and *compounding* have a more limited, special meaning. They refer to only those mixtures in which new substances with new and different properties have been produced.

Terms to Know

mixing
ingredients
powder
manual
portland cement
agitate
stirring
tumbling
mulling
fluidizing
rotates
pneumatic agitation
ultrasonic vibration
dissolve
recover
evaporate
reversible
solution
solvent
suspended
kneaded
rise
barrel rolling
granular
fluid
additives
detergents
volume
metering
viscous
high viscosity
low viscosity
unstable
metered
proportions
dilute
carbonated
compound
properties
mixture
compounding (forming a compound)

Think About It!

1. What are some examples of the mixing of *two solids* and the mixing of *two liquids* that take place in your home?
2. What are some examples of the mixing of a *solid with a liquid* and the mixing of a *gas and a liquid* that takes place in your home?



READING 60

Coating

A wide range of manufactured parts and products are coated. *Coating* may be thought of as putting a layer of one kind of material on top of another. Thus you can see that coating is a way to combine two or more kinds of components, Fig. 60-1. The coating is done to *protect* (keep from wearing out fast) and *decorate* (make good-looking) the part or product that is coated.

Examples of Coating

Painting is a common kind of coating process. You may have heard of *plating*. It too is a coating process. It puts a metal coating on top of a metal surface. Sometimes metal is plated on top of a plastic surface.

This book was made by using several coating processes. The shiny look of the cover is due to a varnish coating that was put on top of the cover stock. Each one of the letters in these words shows up on this page because a coating of ink was put on top of the page as it was printed, Fig. 60-2.

Purposes of Coating

Parts and products are coated for many reasons. Perhaps the most obvious one is to make the product look *attractive* (pleasing). Coatings give products *eye appeal* (good looks). The more eye appeal a product has, the more likely it is that people will want to buy it. Imagine what a new bicycle or a new car would look like without an attractive coat of paint, Fig. 60-3.

There are some products whose coatings are more than just good-looking. The coat-

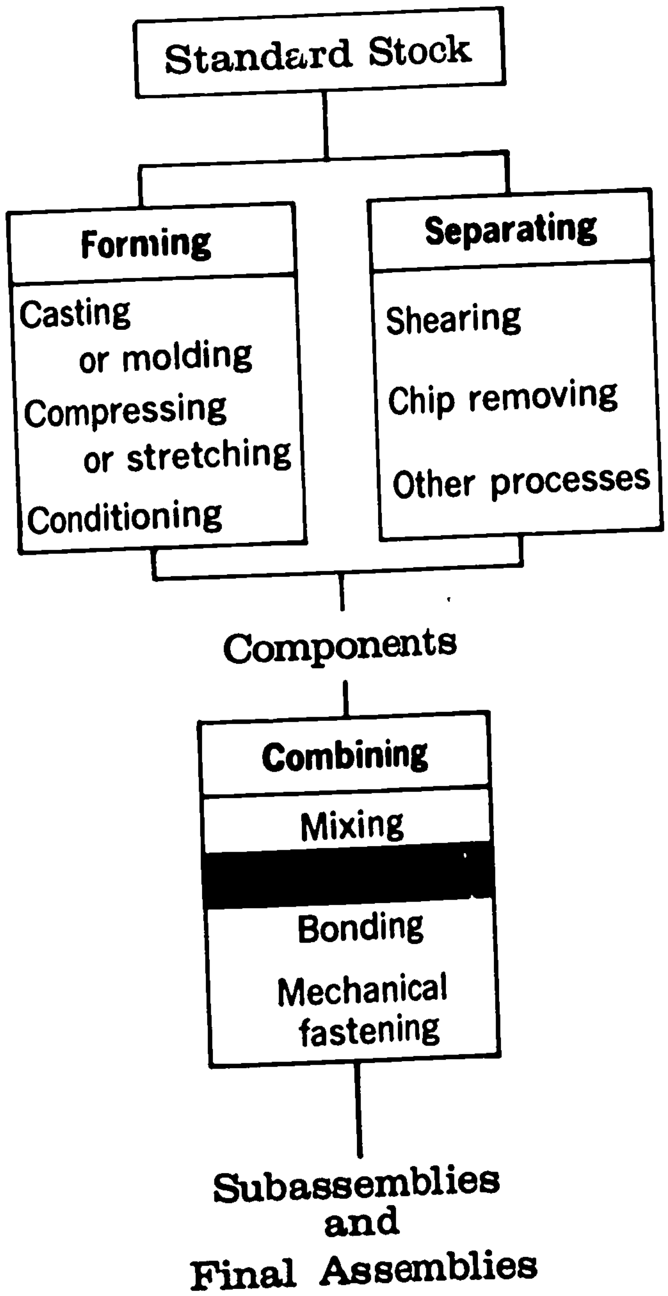


Fig. 60-1. Coating, in the shaded area above, is discussed in this reading.

ings on these products also give us *data* (information). You have already learned that printing ink is a coating for paper. By the use of letters, pictures, and other symbols on paper, we use coatings to *transmit* (pass along to others) data. Some products are painted a special color so that anyone can tell just by looking at them what they are or what they are to be used for. For instance, fire trucks are painted red and school buses are painted yellow. This is done to *identify* them (tell what they are or what they are to be used for) by their color alone.

Coating is also done to protect the surface of parts and products. They are coated to stop rust, Fig. 60-4. They are also coated to stop *corrosion* (wearing away fast), Fig. 60-5.

Imagine what your home would be like if the furniture and other wood products in it did not have coatings of some kind. Without coatings, wood surfaces would get dirty and stay dirty because bits of food, dust,

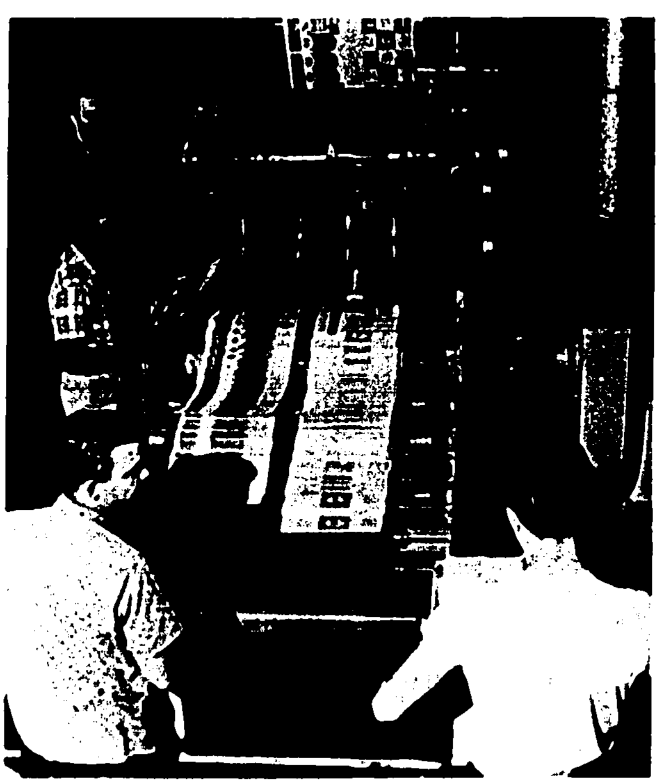


Fig. 60-2. The printing ink used in printing newspapers is a form of coating for paper.

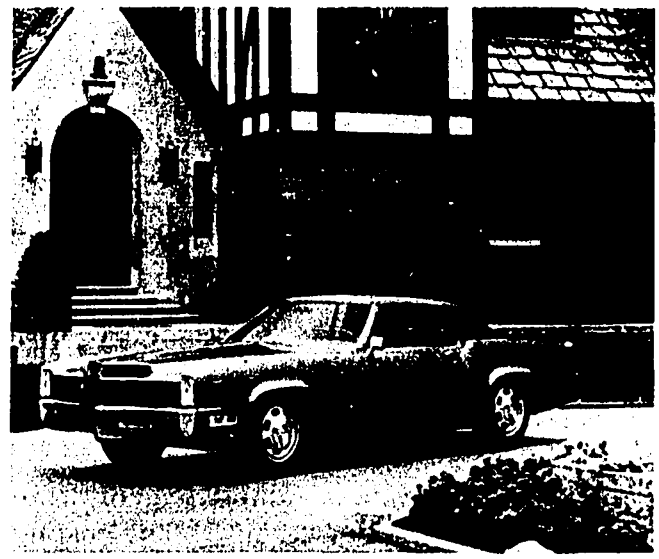


Fig. 60-3. Coating gives a product eye appeal. Imagine how this car would look without a coat of paint.

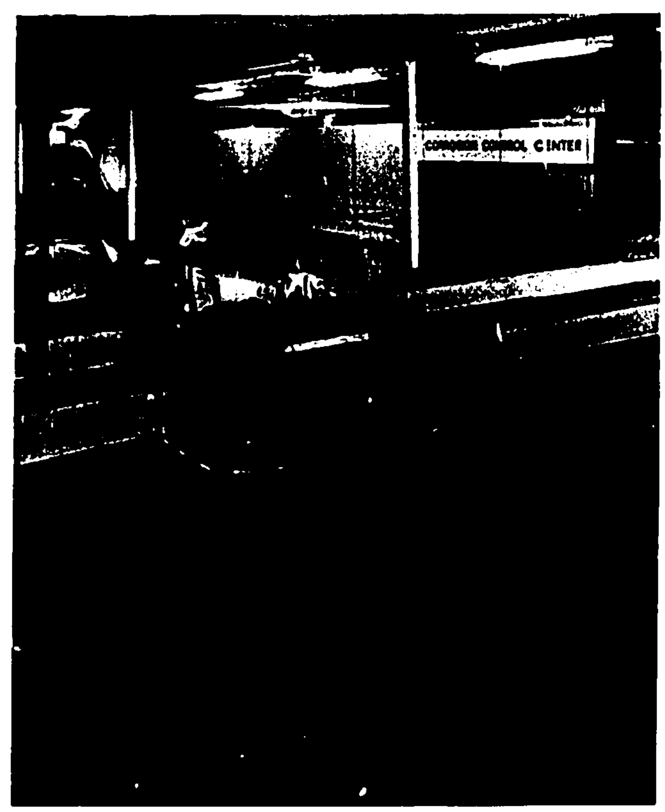


Fig. 60-4. While the conveyor carries these automobile tailpipes through the corrosion control center of this auto plant, the pipes are being coated with a bonderizer to keep them from rusting while they are in storage.

and dirt could get into them. Coatings also make surfaces that can be wiped clean and kept clean.

Fig. 60-5. Coating is done to keep parts from corroding. The parts shown here have been tested in a salt-spray tank. The coated parts are only slightly corroded after the test. The uncoated control part is badly corroded.

Fig. 60-6. Refrigerator shells are being coated with an inorganic nonmetallic coating known as porcelain enamel.

Some coatings *reduce* (cut down on) noise. For instance, the underside of the engine hood of a car is often coated with a substance that will reduce *vibrations* (shocks). Vibrations cause noise. Sound can often be controlled by coatings.

Kinds of Coatings

There are three kinds of coating stock. They are (1) *organic coatings,* (2) *inorganic nonmetallic coatings,* and (3) *metallic coatings.*

Organic stock comes from living plants and animals, or from plants and animals that once were living. For instance, latex, oils, and plastics are organic. Varnish, lacquer, and some enamels are organic. In manufacturing plants, varnish, lacquer, and enamel are often called *paint.* They are usually put on as a thin layer on top of some other surface. Lacquers are the most widely used coatings for manufactured products.

Inorganic stock has never been a part of any living plant or animal. *Nonmetallic* stock (anything that is not metal) gives us *ceramic coatings* and *vitreous enamel coatings* (glass or porcelain enamel coatings). They are made from mixtures of clay, quartz, and other minerals. Ceramic coatings can only be used on material that can *resist* (stand up under) high temperatures. Steel is a good example. Ceramic coatings are common on bathroom fixtures, stoves, sinks, and refrigerators, Fig. 60-6. They protect these products well, and they also make them attractive. Ceramic coatings are often *brittle* (break easily), though, and thus tend to chip.

Metallic (metal) stock is used to coat and plate many products. Zinc, nickel, chromium, and other metals are used as coatings. They stop rust and corrosion. They also make the products good-looking.

Many coatings are made by *mixing.* Sometimes, mixing is needed to get the coating material ready for coating.

Coating Processes

There are two major ways to coat one substance with another. They are (1) *applied coating*, and (2) *conversion coating*. Most coatings are *applied*. A few are *converted*.

Applied Coating Processes

Organic coatings may be *applied* (put on top in a thin layer) by *brushing, rolling, dipping*, or *spraying*. The process that is used depends on the size and shape of the product to be coated. It also depends on how many of this product are being made.

Brushing and *rolling* are usually done by hand. Coatings are put on with a brush or a roller. Brushing and rolling are done for products that are made in small numbers. They are also done for products with special surfaces or pattern designs.

Dipping is an old process. It is still used when products that are made in large numbers have to be coated very fast, Fig. 60-7. It is not the best process to use, though. The thickness of the coating is not *uniform* (the same all over the product). The lower edge or corner gets a lump of *excess* (extra) coating that may not look good. This extra coating may even keep the part from being *assembled* (put together with other parts), or from working well after it is assembled. Metallic coatings may be put on by *dip-coating*. Galvanized steel is steel that has been hot dip-coated with zinc.

Spraying has become a common way to coat a surface, Fig. 60-8. All kinds of coatings can be put on by spraying. Some of the coating may be lost as it is being sprayed, because not all of the spray hits and sticks on the surface being coated. In *electrostatic spraying*, droplets of the spray are given a positive electric charge. The part or product being coated is grounded. The charged coating droplets are then electrically pulled to the product. Thus very little of the coating spray is lost. The coating is also very uniform in thickness.

Ceramic coatings are often put on by spraying. After the piece of standard stock is coated, it is *fired* (baked) at a very high temperature. Heat makes the particles of ceramic coating *fuse* (melt and run to-

Fig. 60-7. Tank dipping is an old process used to coat rapidly those products that are made in large quantities.

Fig. 60-8. Spraying has become a common process for applying coatings. Here paint is being sprayed on new car bodies. The paint coating protects the metal and also makes the car attractive.

gether) like glass. In fact, a porcelain enamel coating is a layer of glass, though it is not *transparent* (easily seen through) like window glass. *Flame spraying* is used to coat nose cones of rockets with ceramic coatings.

Metal vaporizing quickly *deposits* (lays down) a very thin layer of metal on a surface. Glass mirrors are made by coating glass with a layer of aluminum.

Electroplating coats one metal with another, Fig. 60-9. Many metal coatings are put on this way. These include zinc, copper, nickel, chromium, cadmium, tin, brass, silver, and gold. Some metals plate better to one metal than they do to others. Some electroplates are much more *durable* (long-lasting) than others are.

Electroplating takes place in a tank of water in which a metal salt has been *dissolved* (melted). The water-and-salt solution is called an *electrolyte* because it lets electric current pass through it. Bars of plating metal are attached to the positive terminal of a battery and then placed in the solution. The *workpiece* (part being plated) is attached to the negative terminal of the battery and also placed in the solution. When the electric current is turned on, it takes molecules of metal from the bar into the water-and-salt solution and then puts them on the surface of the metal workpiece. The workpiece must stay in the tank a certain length of time in order to get the right thickness of plating. It is then taken out, rinsed, and dried. Electroplating is widely used to get metallic coatings for products.

Fig. 60-9. Electroplating coats one metal with another. The metal disks are in the process of being electroplated in the tanks below.

Conversion Coating Processes

In the coatings you have read about so far, the workpiece is covered with a different substance. There are a few kinds of material that can be made to "grow" their own coatings. For instance, a piece of aluminum stock will make an aluminum oxide surface layer from its own molecules of aluminum. Since some of the substance of the part itself is *converted* (changed) into a different substance, the process is called *conversion coating*.

Aluminum can be made to "grow" its own coating in a process called *anodizing*. The process takes place in an electrolyte tank. The electrolyte is *dilute* (thinned down) sulphuric acid. The *voltage* (electric pressure) used in anodizing is about four times as great as that used for electroplating. A *complex* (complicated) aluminum oxide is thus formed on the surface of the metal itself.

After aluminum is anodized, it is dipped into hot water to seal the surface. Often, colored dyes are added to the hot-water dip. Aluminum glasses and bowls are often colored in bright shades of red, blue, and green by this process. Aluminum can also be made to look like copper, gold, or silver.

Anodizing is quite different from metal electroplating. It is sometimes called *reverse plating*. It is widely used to coat aluminum. Another metal, magnesium, is sometimes anodized.

Summary

A coating is a surface layer of a substance that is different from the piece of stock underneath. Such coatings are called applied coatings. A few coatings are made by changing the surface of the workpiece itself.

Coating may be done to protect a part or product. It may be done to make it easier to clean. It may be done to add to its eye appeal. It may be done to pass along some information. It may be done to reduce noise or to reflect light.

Three kinds of surface layers are applied as coatings. They are (1) organic coatings, like enamel and lacquer; (2) inorganic nonmetallic coatings, like porcelain enamel; and (3) metallic coatings, like zinc, copper, nickel, and brass.

In an applied coating process, the coating layer sticks to the part or product being coated. In a conversion coating process, a chemical change takes place on the surface of the coated part. Most coatings are applied. Only a few are conversion processes.

Terms to Know

coating
protect
decorates
painting
plating
attractive
eye appeal
data
transmit
identify
corrosion
reduce
vibrations
organic coatings
inorganic nonmetallic coatings
conversion coating
applied
brushing
rolling
dipping
spraying
uniform
excess
assembled
dip-coating
electrostatic spraying
fired
fuse
transparent
metallic coatings
organic
paint
inorganic
nonmetallic
ceramic
vitreous enamel (porcelain enamel)
resist
brittle
metallic
mixing
applied coating
flame spraying
metal vaporizing
deposits
electroplating
durable
dissolved
electrolyte
workpiece
converted
anodizing
dilute
voltage
complex
reverse plating

Think About It!

1. What other products can you name besides fire extinguishers and school buses that have *coatings* that *transmit information?*
2. Look at a store display. What products have been coated for *eye appeal?* For *protection?*

Bonding

READING 61

Bonding is one of the major ways to *assemble* (join) solid parts, Fig. 61-1. The place where the two parts are joined is called the *joint.* The joint is always *rigid* because neither part can turn or move. Some bondings join two parts with glue, cement, or some other *adhesive.* In other bondings, the parts themselves melt or soften at the joint. The melted surface layers run together. After they cool, they are *fused* (joined).

In this reading, you will learn about two major ways to bond solid parts. They are (1) *fusion bonding* and (2) *adhesive bonding.*

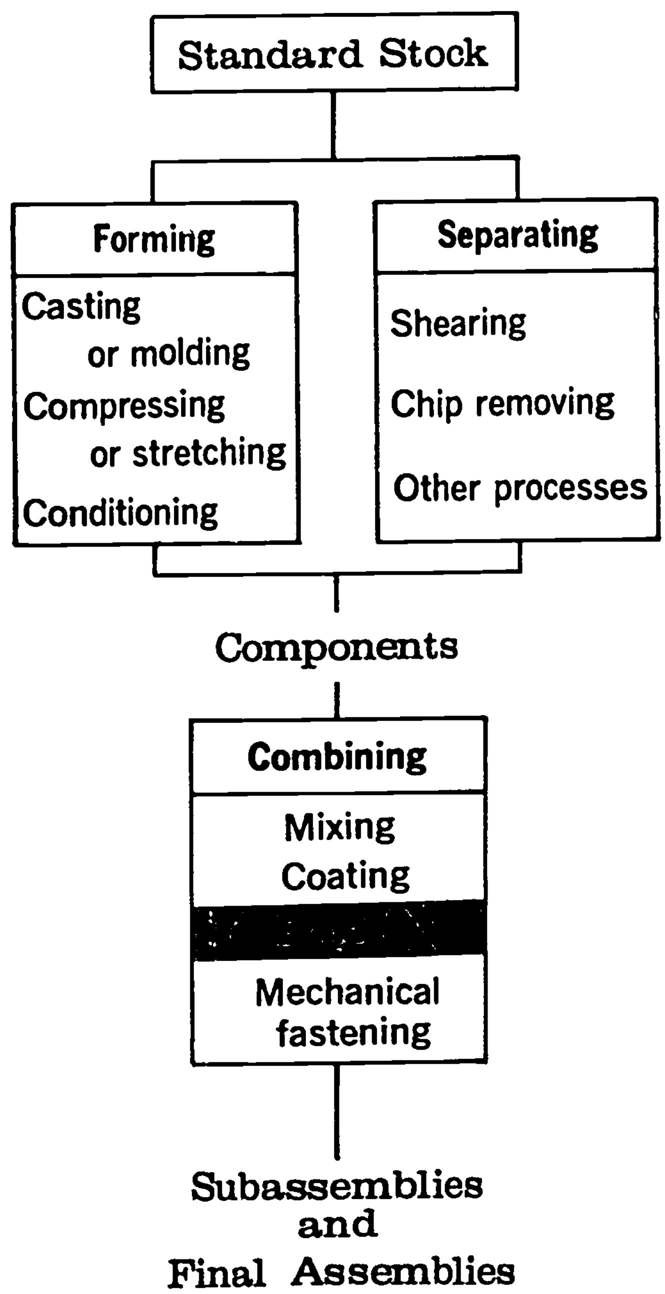


Fig. 61-1. Bonding, in the shaded area above, is discussed in this reading.

Fusion Bonding

When two parts are joined in a bond, the surfaces that touch or meet are called the *interface* (the "face between"). In *fusion* bonding, molecules from each part move across the interface and mix with molecules from the other part. The parts are said to *fuse* (become one).

The most common kinds of fusion bonding are welding, high-temperature brazing, and high-temperature soldering. Some plastics can be bonded by fusion. Fusion bondings are meant to be *permanent* (long-lasting).

During fusion bonding, the interface surfaces of the two parts must be held tightly together. There must be no *projections* (bumps) to keep them apart. They must also be very clean.

To get molecules of the two parts to move across the interface and mix with each other, the motion of these molecules must be speeded up. This can be done by heating the parts at the interface. Great amounts of

pressure (force) can also fuse the parts at the interface.

In some fusions, the metal at the interface is heated without any extra pressure placed on it. Forcing the parts to join without adding heat is called *cold welding.* In most fusions, though, heat is combined with pressure.

When the metal at the interface is fused by heat, a filler metal is usually added to fill the joint. See Figs. 61-2 and 61-3. If this filler is a metal that is very much like the metal in the parts, the bonding process is called *welding.* If the filler is a metal that is very different from the parts, the bonding process is called *high-temperature brazing,* Fig. 61-4. For instance, a brass wire filler would be used in *welding* two brass parts. The same kind of brass wire could be used in *brazing* two cast-iron parts.

Interface surfaces must be cleaned before they are fused. They may be cleaned by washing them or by *fluxing* (brushing them with a substance like rosin). Fluxing is done to remove *oxides* (impurities), Fig. 61-5.

There are many ways to speed up the motion of metal molecules so that fusion will take place. In welding, heat is used. The heat energy can come from an oxyacetylene torch. It can come from an electric arc, Fig. 61-6. It can come from *electrical resistance* (heat built up when a substance resists the passing of a steady electric current through it), Figs. 61-7 and 61-8. It can come from

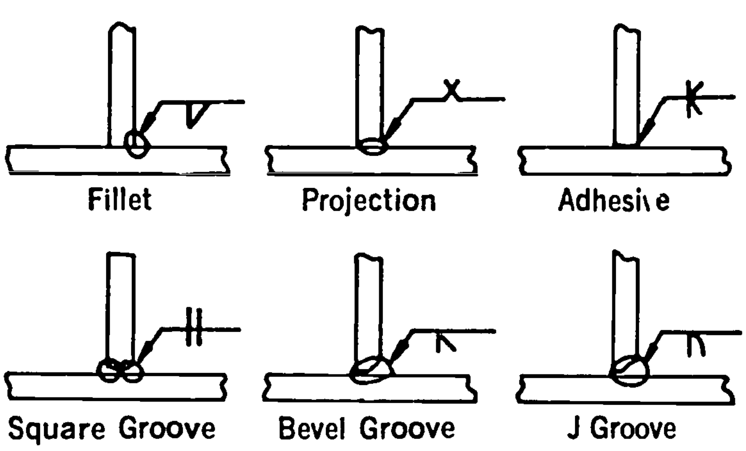


Fig. 61-2. Shown here are six kinds of tee joints used in bonding processes.

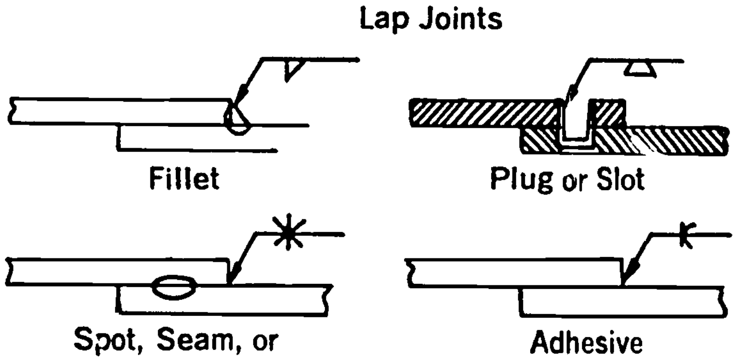


Fig. 61-3. Shown here are four kinds of lap joints used in bonding processes.

Fig. 61-4. Brazing is one of the most common ways of fusion bonding. This worker is brazing a fuel assembly of an irradiation experiment.

ultrasonic vibration (heat built up from shocks made by very high-pitched sounds).

There are extreme temperature changes produced during welding. These can cause *stresses* (forces) to develop inside the welded assembly. The joint itself may be very strong, but a narrow band on either side of the weld is weakened because of

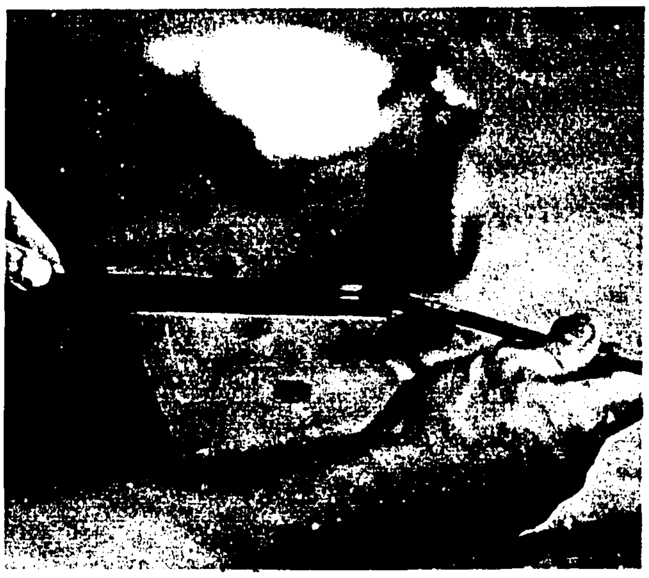


Fig. 61-5. Interface surfaces may be cleaned by fluxing. Fluxing is done to remove oxides.

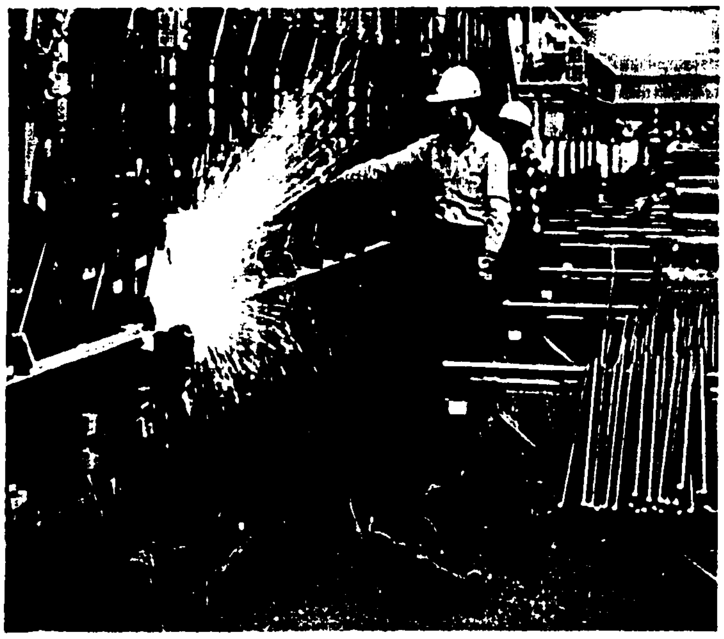


Fig. 61-7. Resistance welding is another way of fusion bonding. It is being used to weld the metal components you see on the rack to the right.

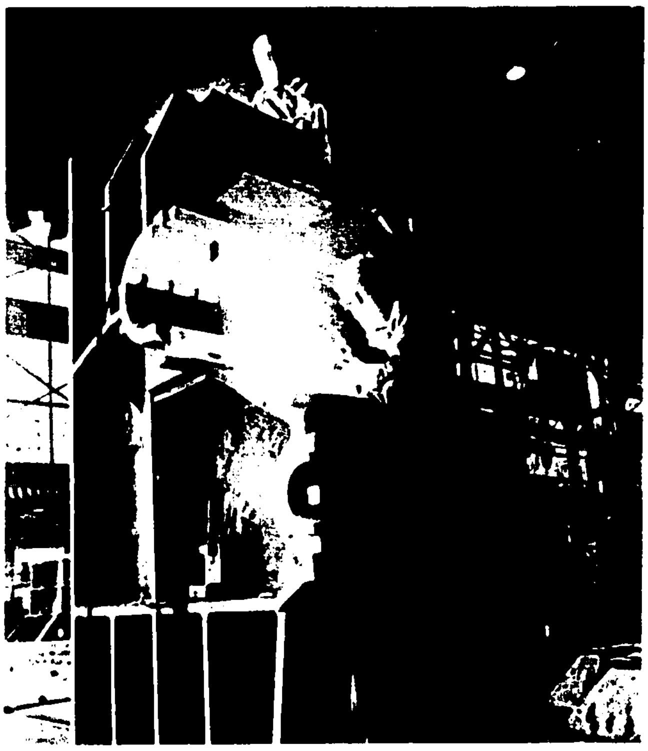


Fig. 61-6. These welders are using the electric arc welding process.

Fig. 61-8. Parts of this automobile body are being fused by resistance welding.

these stresses, Fig. 61-9. If the assembly is put inside a heat-treating furnace, the stresses can be removed. The assembly then has the same strength throughout. If it is done well, fusion bonding makes a neat-looking assembly.

Adhesive Bonding

In *adhesive bonding*, the *adhesive* (glue, cement, or paste) is *applied* (put on) in a thin layer at the interface of the parts being joined. The molecules of the adhesive stick or cling to each surface.

Some adhesives *set up* (harden) to form a long-lasting rigid bond. Some adhesives stay *tacky* (sticky) after they are put on. A wood chair leg glued to the frame of the chair is an example of a hard long-lasting bond. See Fig. 61-10. A piece of adhesive tape on your arm is an example of an adhesive that stays tacky.

Some adhesives are put on at the factory but not used right away. Examples are iron-on patches for clothes, adhesive tapes for sealing boxes, gums for sealing envelopes, and ready-pasted wallpaper. See Fig. 61-11.

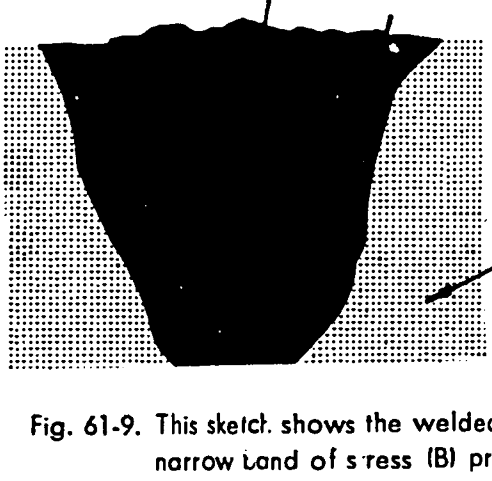


Fig. 61-9. This sketch shows the welded joint (A), the narrow band of stress (B) produced by the welding process, and the rest of the fused assembly (C) not affected by the welding process.

Other adhesives must be made and applied just before the product is used. These are used to repair furniture, to lay *resilient* (springing back to shape) flooring, to attach

Fig. 61-10. This worker is coating ceramic cup parts with "slip" (liquid clay). The clay is an adhesive bonding.

Fig. 61-11. This continuous strip of asphalt roofing material has been looped over hangers and hung to dry. This type of roofing material is made by putting asphalt into strips of organic felt and then coating them with a surface grit.

plywood wall panels, and to hang chalkboards.

Many of the adhesives called *pastes* are made from starch. Perhaps you have cooked a flour-and-water mixture to make paste to hang wallpaper or do papier-mache work.

Many of the adhesives called *glues* are made from animal protein. Man has known how to make bone glue and fish glue for a long time.

In the past few years, new *glues* or *cements* have been found. There are several plastic resins that have been found to be very adhesive. Manufacturing now uses them in a great many ways.

There are *thermoplastic resins* that soften when they are heated and harden when they are cooled. They may be used for temporary assemblies, since they lose their strength when the temperature gets much above 120°F.

There are *thermosetting plastics* that harden when heat and pressure are applied. When they are heated again, they do not soften. Thus bondings with these adhesives are permanent.

Adhesives are used in such widely different industries as airplane assembling and bookbinding. Look at a ping-pong paddle, a shoe, or a boat. Can you see where parts have been bonded with adhesives?

In a process called *laminating*, pieces of sheet stock can be bonded in layers. This is done to make them stronger and longer-lasting. Plywood is a laminated product. It is built up from layers of wood, with the grains in touching layers running in opposite directions. A bonding adhesive is placed between the layers. Then the plywood "sandwich" is processed by special machines to make the bond last longer.

Fabrics can also be laminated. Laminated clothing and furniture fabrics may have an outer layer that is chosen for its beauty bonded to an inner layer that is chosen for its strength or warmth.

A very hard durable plastic can be bonded to plywood or to other sheet stock. This is done to form finish stock for counter tops. The plastic surface layer can be made in many different colors and patterns. In the same way, wall paneling and resilient flooring can be made with surfaces that are long-lasting, attractive, and very easy to clean, Fig. 61-12.

Bonding adhesives and techniques are always being improved. Their uses in industry will grow in future years.

Soldering and Brazing

Metal adhesives are a special kind of adhesive. There are *low-temperature soldering* and *brazing* metals. These metals melt during bonding, but the parts they are joining do not melt at the interface.

Low-temperature soldering and brazing depend on the fact that certain metals have an *affinity* (a kind of attraction) for each other. For instance, when tin-lead solder is melted over *fluxed* (clean) copper, the solder forms a very tight coating on the

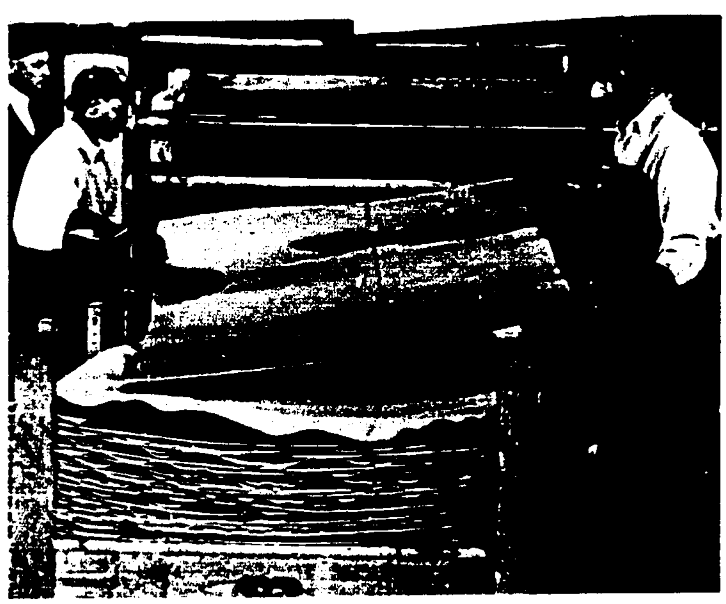


Fig. 61-12. Veneer used in making plywood is being fed into the glue-spreader. After the glue is spread on one surface of the veneer, another piece of veneer is placed on it. Then the two pieces are pressed together. Many layers of veneer can be put together in this way.

copper, Fig. 61-13. We say that it "wets" the surface, even though there is no water and no mixing of the molecules of either metal part.

Advantages of Adhesive Bonding

It often costs less to make a joined assembly from parts that have standard shapes than it costs to cast and machine one *complex* (complicated) assembly. Such assemblies as structural steel frames for buildings and bridges, or the frames of large machine tools, can be permanently bonded on the *site* (location) where they will be used.

There are adhesives for bonding almost any material to another. With the right choice of adhesive, bonding can be made to last for a short time or for a long time. Most adhesive bondings are meant to last for a long time.

Summary

Bonding joins solid parts into a rigid assembly. There are two basic ways of bonding. They are (1) *fusion bonding,* and (2) *adhesive bonding.*

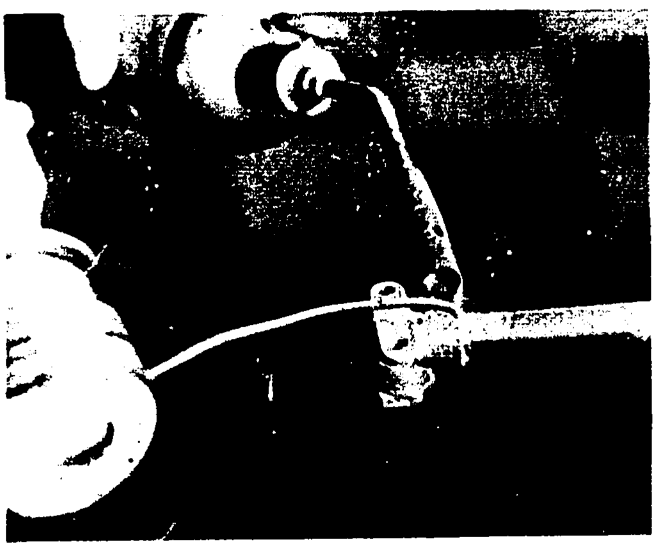


Fig. 61-13. A special form of adhesive bonding is soldering. Here a pipe joint is being soldered.

In fusion bonding, molecules at the interface of the parts run together (fuse). The two most common ways of fusion bonding are welding and brazing.

Adhesive bonding does not fuse the molecules of the joined parts. Instead, the molecules of the adhesive stick or cling to both parts. Pastes, glues, and cements are common adhesives. Some adhesives harden. Others stay tacky. Low-temperature soldering and brazing use metal adhesives.

Industry uses all these adhesives and some other newly-found ones. These include several plastic resin adhesives that are very strong and last a very long time.

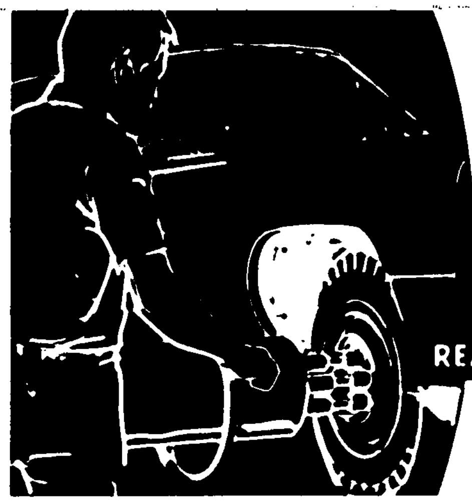
Terms to Know

bonding
assemble
joint
rigid
adhesive
fused
fusion bonding
adhesive bonding
interface
fuse
permanent
projections
pressure
cold-welding
welding
high-temperature brazing
brazing
fluxing
oxides
electrical resistance
ultrasonic vibration
stresses
applied
set up
tacky
resilient
pastes
glues
cements
thermoplastic resins
thermosetting plastics
laminating
low-temperature soldering
low-temperature brazing
affinity
complex
site

Think About It!

1. In your home, what kinds of products can you find that were *fusion bonded* in assembling them at the factory?
2. In your home, what kinds of products can you find that were *adhesive bonded* before you got them? After you got them?

Mechanical Fastening



READING 62

Mechanical fastening is quite different from the other ways to combine parts you have learned about. Before you started to read this book, you probably already knew more about this way to combine parts than you did about the others.

Mechanical fasteners were used long before men began to write down what they were doing and thinking. Tying, lacing, sewing, pinning, and nailing are all very old ways of mechanical fastening. Modern fasteners include threaded bolts and nuts, zippers, snap hooks, swivels, and door hinges. In this reading, you will learn about some of the ways in which they work and some of their uses, Fig. 62-1.

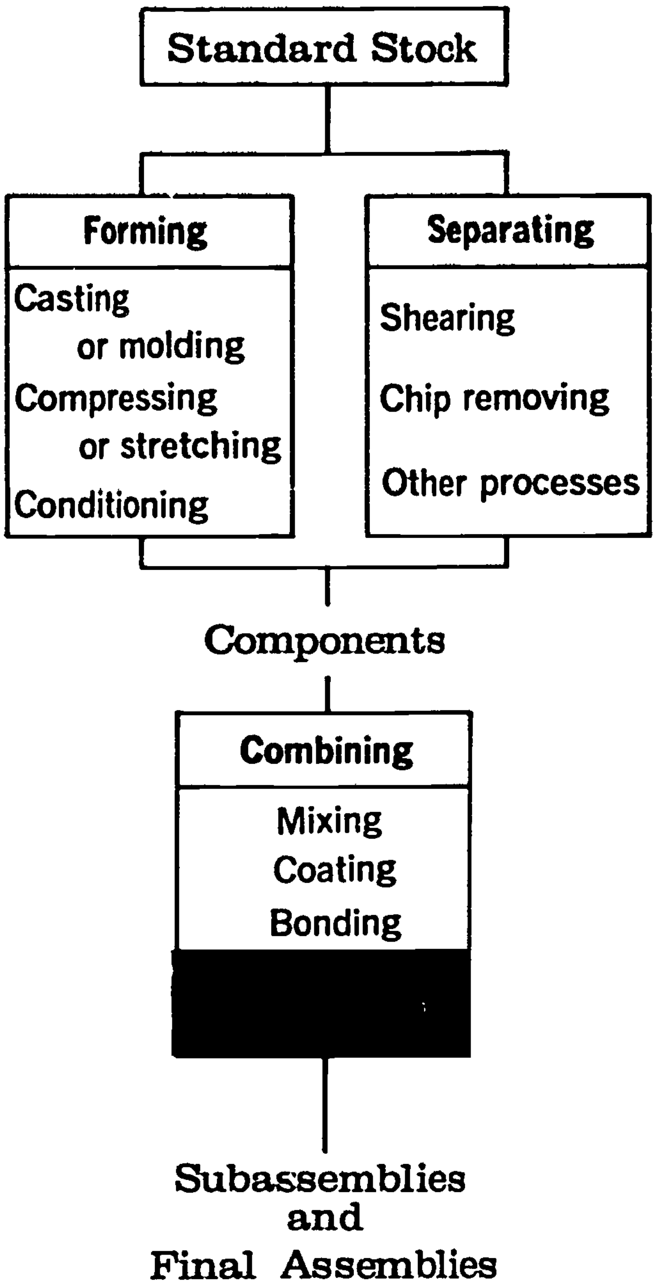


Fig. 62-1. Mechanical fastening, in the shaded area above, is discussed in this reading.

Fastening with Nails and Staples

Nails and *staples* are very common in *assembling* (combining) wooden parts. They are used a great deal in cabinetmaking and in constructing wood-frame housing, Fig. 62-2.

Nails and staples come in many different styles and sizes. *Tacks*, *brads*, and *spikes* are names of nails that come in special sizes and shapes, Fig. 62-3. Some nails are *serrated* (grooved). Some are coated so that they won't work loose from the wood.

When a nail is driven into a piece of wood, some of the wood fibers are pushed aside. The wood around the nail is *compressed* (squeezed together). As long as the wood does not shrink or crack, it will keep on pushing against the nail and holding it in place. Nailed assemblies are held together by the strength of this *resistance* (pushing back). This kind of resistance is called

friction. Other assemblies that are combined with mechanical fasteners are also held together by this kind of friction.

Staples are used to fasten papers, cartons, magazines, cloth, and baskets, Fig. 62-4. There is not enough friction to hold straight staples in *flexible* (easily bent) materials like paper. Therefore the ends of staples driven into paper *clinch* over (bend over).

Fig. 62-2. Many nails are used in constructing wood-frame housing.

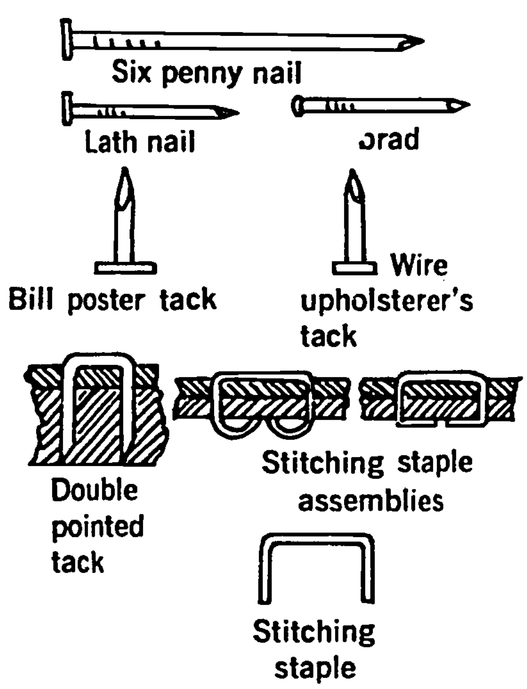


Fig. 62-3. Here are shown some of the many different kinds of nails and staples.

Fastening with Threaded Devices

Many products are made of parts that are held together by *threaded fasteners.* Bolts and screws are the most common of these.

Threaded fasteners have screw threads, Fig. 62-5. *External screw threads* are ridges wrapped around the central *core* (body) of the fastener. *Internal screw threads* are made inside a hole in a part or in a nut.

Bolts have external threads, and nuts have internal threads. Most bolts must have nuts to fasten parts of a product together. Screws that are used in soft stock like wood, or in thin material like sheet metal, cut their own internal threads. They do not need threaded nuts to *lock* (hold) parts together.

There are other assemblies that are held together by threaded fasteners. For instance, many kinds of pipe and fittings are threaded. A common light bulb is held in its socket by threads.

Fig. 62-4. Staples were used to assemble the parts of these baskets.

The resistance of friction is what holds most threaded assemblies together. The *holding power* of a threaded fastener refers to the number of threads per inch. In general, the greater the number of threads per inch, the greater the holding power will be.

Devices for Lacing, Sewing, and Strapping

Lacing is a very old way to tie things together. Primitive man used leather strips very much like modern shoe laces. The large holes in his leather clothing were not made by machines, of course, but lacing and tying things worked for him just as they do for you.

Sewing is a lot like lacing. After sewing, though, the cloth or leather parts usually have a great many small holes, instead of a few large ones. Instead of a short strip of leather, the lacing is usually a long piece of *thread*. Thread is much finer and thinner than the primitive man's lacing.

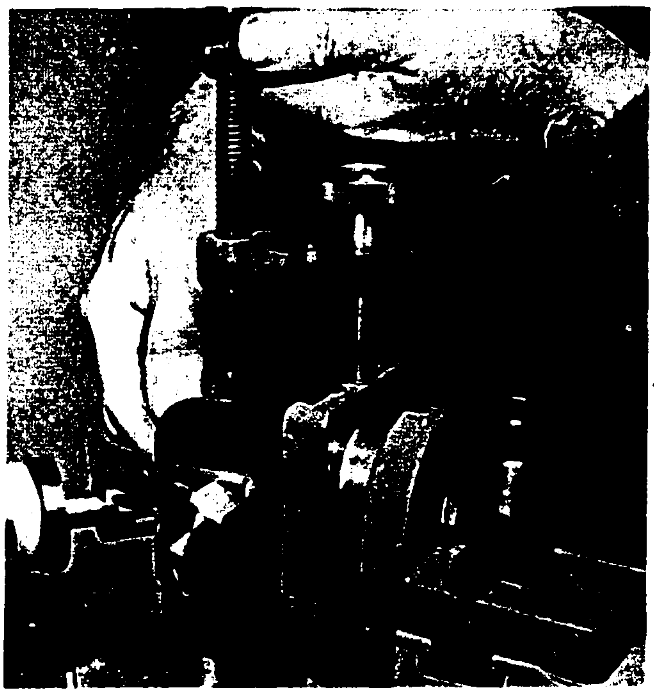


Fig. 62-5. This clamping device uses many different screw threads to hold the clamp and the workpiece in place.

Modern sewing is different from lacing in one other way. The thread is sewn into the parts by machines, Fig. 62-6, since clothes are now *mass-produced* (made in very large numbers of the same product or part).

Thread is used to assemble the parts that make our clothes, tents, sails, furniture covers, bedding, and leather goods. *Twine* (heavy cord) is used when the fastener must have more strength to hold the parts together than thread has. Twine is often used to close the sacks of such products as flour, sugar, grass seed, and lawn fertilizer.

Flat metal *strapping* is used to fasten together the parts of wooden crates and boxes. Wire and straps are widely used in assembling bed springs and mattresses.

Besides thread, lacings, and straps, there are several other kinds of mechanical fasteners: rope, wire, cable, and chains.

Devices That Allow Movement of Parts

Some parts must be assembled so that one is free to move while the other is not. A door must swing open. Wheels must turn. In a car engine, pistons must move back and forth in cylinders. During the past century,

Fig. 62-6. This worker is sewing together sections of a Persian lamb coat on a machine.

a great many different devices have been used in assemblies with movable joints. Many have pins that pass through the parts in such a way that only one of the parts can move. A common door hinge works this way. The hinge plate on the door jamb does not move. The hinge plate on the door, though, does move. The hinge pin should "float" freely, but it really sticks to one of the plates in most assemblies. If it stuck to both plates, the door could not swing open.

Fastening with Other Devices

Cotter pins, retainer rings, and clips are used in assemblies that have to be taken apart later on for repairs or changes, Fig. 62-7. Dowel pins, shear pins, keys, and splines are fasteners that hold parts together *rigidly* (so that none of them can move or turn). *Rivets* are widely-used fasteners. A rivet is a pin or bolt with a head at one end, and a way of spreading the other end after the rivet has been put into place. Riveted joints must last as long as the parts they hold together.

Fig. 62-7. A tire weight is being clipped to the rim of the tire.

Fastening by Interference Fits

Two parts can be designed to fit in such a way that friction is the only thing that holds them together. Therefore no separate fasteners are needed. This is called fastening by *interference fit*. The tightness of the fit is fixed by the design engineer, since he sets up the *dimensions* (sizes) of the matching surfaces of the parts to be fastened. Such fits can be very loose or very tight, depending on how the assembly is to be used.

Summary

Many different mechanical fasteners are used to assemble parts, Fig. 62-8. Most assemblies that are mechanically fastened are ones that can be taken apart later on for repairs or changes. Only a few of them last as long as the parts they hold together.

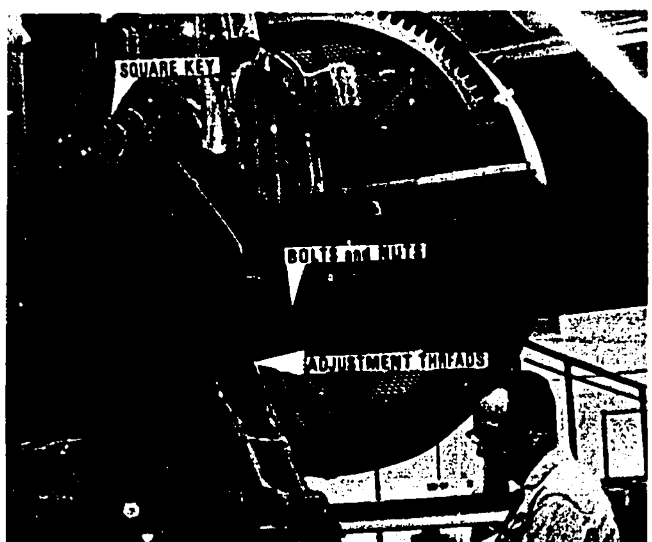


Fig. 62-8. Many of the parts of this press are assembled with mechanical fasteners. How many examples can you find in the picture?

Mechanical fasteners include nails and staples; threaded fasteners like bolts and screws; thread, wire, and strap; cotter pins, keys and splines, and rivets. Each one is used in a different way to fasten different kinds of parts into assemblies. Many of them allow one part to move while the other stays rigid. The common door hinge is an example.

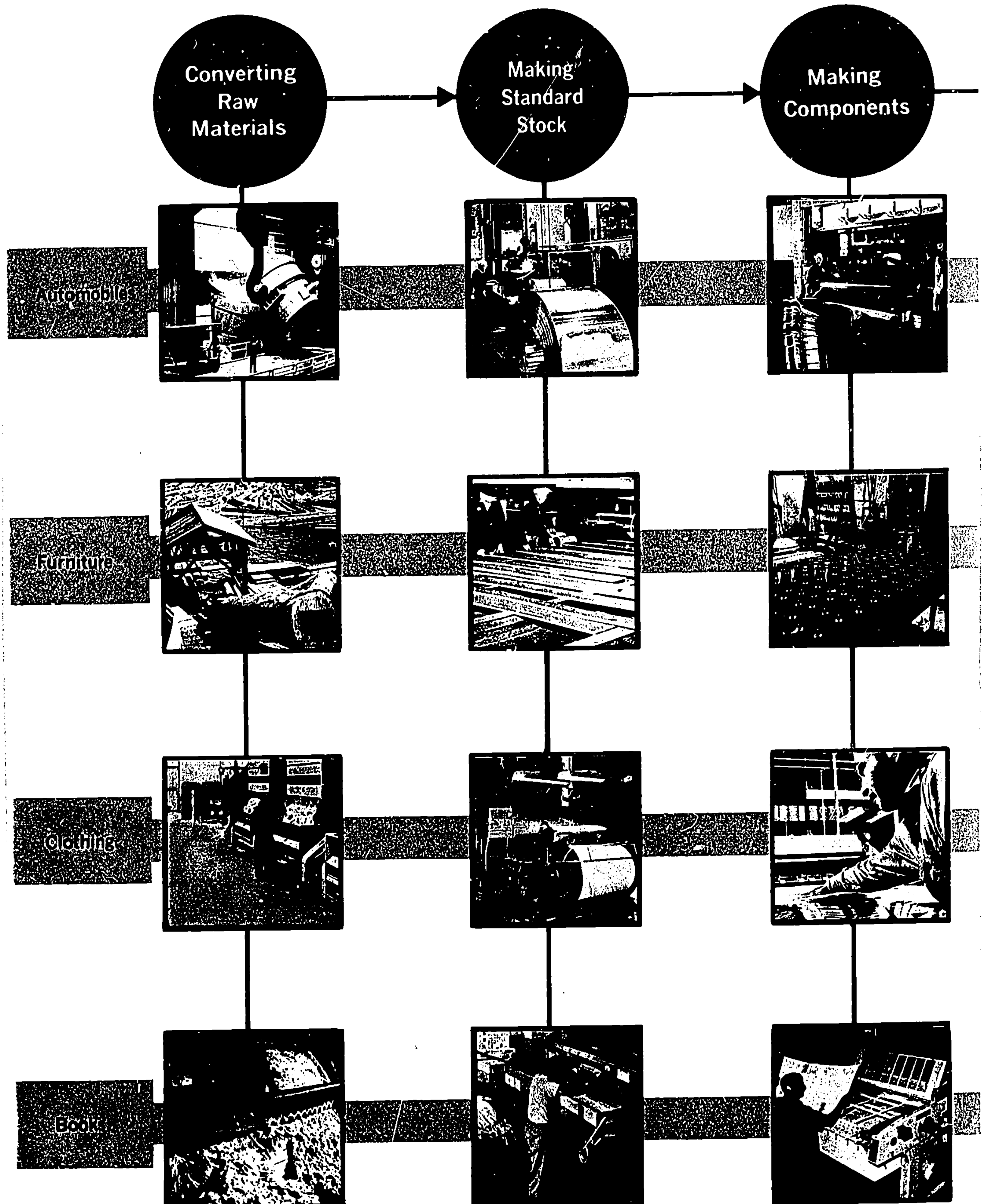
Mechanical fastening can also take place through interference fit. The parts are designed and made so that they fit together by friction alone.

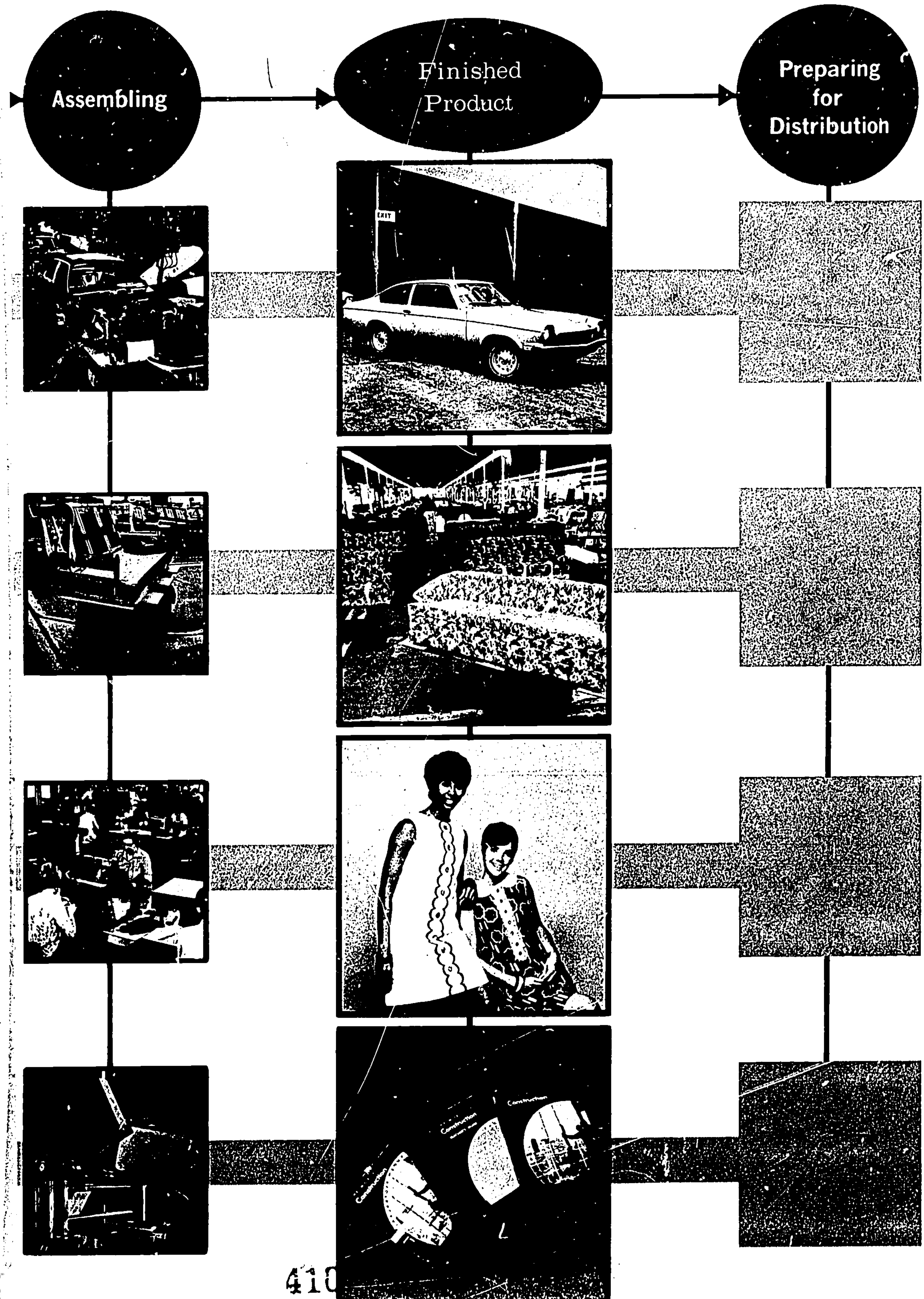
Terms to Know

mechanical fastening	core	compressed	strapping
mechanical fasteners	internal screw threads	resistance	rigidly
nails	lock	friction	rivets
staples	holding power	flexible	interference fit
assembling	lacing	clinch	dimensions
tacks	sewing	threaded fasteners	identify
brads	thread	external screw threads	threaded devices
spikes	mass-produced	twine	
serrated			

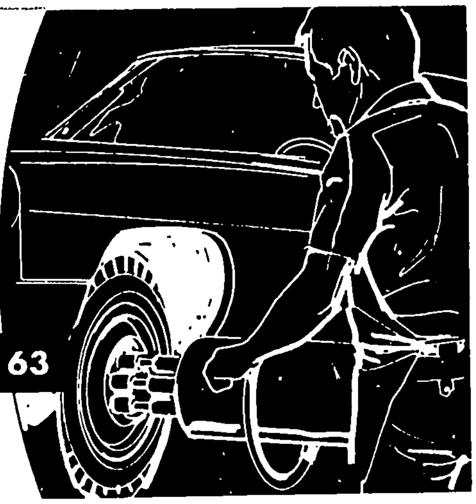
Think About It!

1. Look at a toaster, mixer, blender, or some other small appliance. Can you *identify* (name) the kinds of fasteners that are used in one of the products?
2. Identify three products in your home that have been fastened by:
   a. *nails* and *staples*
   b. *threaded devices*
   c. *lacing*


Converting Raw Materials
Making Standard Stock
Making Components
Automobiles
Furniture
Clothing
Books


Assembling
Finished Product
Preparing for Distribution

READING 63



Combining Subassemblies

So far in these readings, you have learned that materials are formed and separated to make *components* (parts) or simple one-piece products. You have also learned that some parts are combined with other parts into *subassemblies* (smaller units that are combined into larger units) or into finished products.

In these readings, you have learned how parts are joined or combined into assemblies. They are joined by (1) *mixing,* (2) *coating,* (3) *bonding,* and (4) *mechanical fastening.* In this reading, you will learn how all of these are used to form subassemblies or to combine subassemblies into more *complex* (complicated) finished products, Fig. 63-1.

The Assembly Process

Assembly (combining parts) is a very important phase of manufacturing. The assembly process brings together all of the parts and subassemblies for each product. These parts and subassemblies must be combined so the product will operate or function according to specifications.

Quality control (those actions needed to make sure the product meets the specifications) of subassemblies and assemblies is even more important than it is for their parts. A part that is scrapped because of a *defect* (poorly made) costs a great deal in time and money to replace or to make over again. But the money and time lost when a whole assembly must be torn down to replace a *defective* (poorly made) part are even greater. For instance, in the auto industry, it is not too unusual for a plant to lose $30 to $50 of labor time just to replace

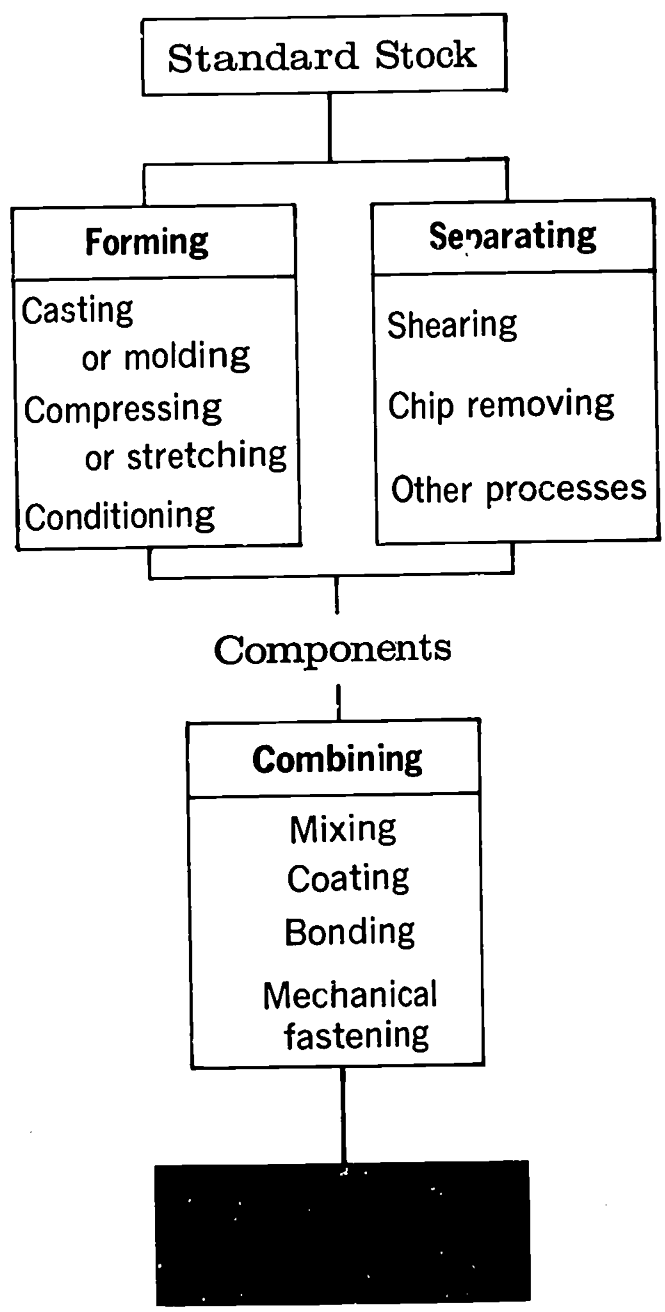


Fig. 63-1. Subassemblies and final assemblies, in the shaded area above, are discussed in this reading.

411

a defective *component* (part) or subassembly that costs only 15 to 30 cents.

Assembly may be thought of in two different ways:

1. Assembly may be thought of as those combining processes, especially bonding and mechanical fastening, that are used to put parts together into subassemblies or final assemblies, Fig. 63-2.
2. Assembly may be thought of as a materials-handling system in which all parts of a product must flow together at the right time and at the right place, Fig. 63-3.

The physical plant must be set up in the right way. The right number of parts and subassemblies must always get to the right places at the right times. The right kind of materials-handling machines and tools must be there when they are needed. Of course, the system is not complete without the right number and the right kind of assembly workers and tools.

There are two major ways to set up the assembly of parts and subassemblies. They are (1) *batch (or lot) assembly,* and (2) *continuous assembly.* The term "parts" refers to liquid, gas, or solid parts that will be combined with other parts to make subassemblies.

Batch or Lot Assembly

Sometimes a product is assembled in batches or lots of small quantity. This may be the cheapest way to do it for many reasons. Assemblies that have major parts coming from a single treatment, mix, or shipment may have to have special assembling, quality control, and tests of how well they meet the specifications. If the product has several slightly different models or formulas, it may be cheaper to make the product in batches. This way, the right quantity of each product can be kept on hand to fill orders from customers. *Batch (or lot) assembly* is most often used if only a small number of the product will be sold. It is also

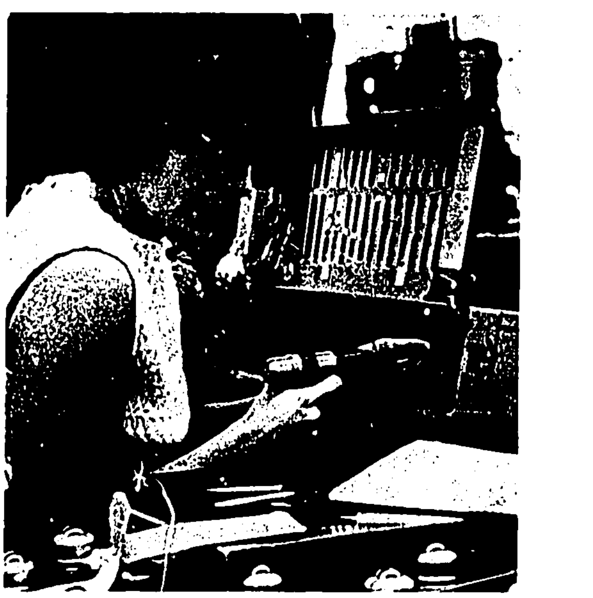


Fig. 63-2. This worker is assembling an electronic unit for use in a telephone system. She is working from a detailed checklist made up by a manufacturing engineer.

Fig. 63-3. These assembly-line workers are part of a system in which all parts of a product must flow together at the right time and at the right place.

used when the demand for the product is *seasonal* (sold only at certain times of the year). Batch (or lot) assembly usually cuts down *production volume* (number of products made) and raises the cost of assembling.

Continuous Assembly

Continuous assembly is best when the same product is being made all the time. For instance, aspirin tablets and white paint are best produced this way. The *continuous assembly line* can make a large number of products. But tooling costs are high. Thus in order to set up such an assembly line, there must be a large and steady demand for the product.

The assembly line is like a river, Fig. 63-4. To keep this river flowing, there must always be plenty of parts, subassemblies, and standard fasteners at the points on the line where they will be needed. Men and machines must work together to *position* (put in place) and *fasten* (join) or *mix* (blend) these parts and subassemblies. The final assembled products then flow out to the sea of customers through a system of *product distribution* (ways of getting the product to the customer when he wants or needs it).

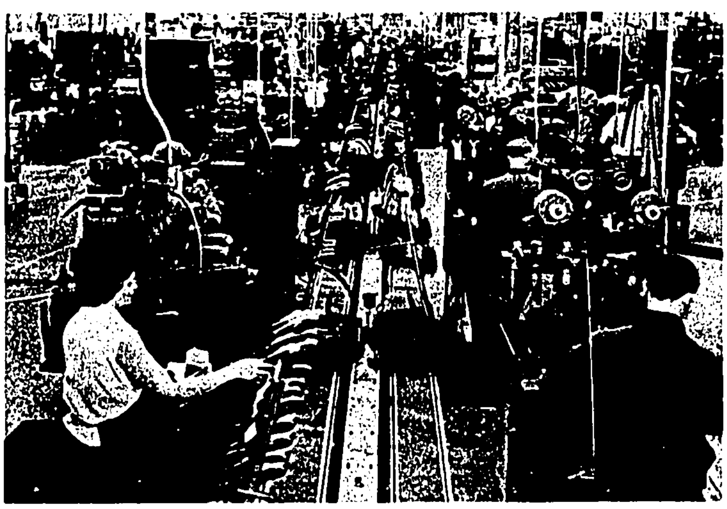


Fig. 63-4. This continuous assembly line in a modern shoe factory shows the shoes moving through the lasting room where they are shaped to fit people's feet.

The Assembly-Line Worker

The *assembler* (assembly-line worker) can be unskilled, or he can be very highly skilled. How skilled the worker must be depends on what kind of assembly work he must do. For instance, the worker who is putting nuts on a threaded rod does not need as much precision and control as one who is mixing drugs that are to be made into medicines. Workers who assemble suits of clothes, wrist watches, transistor radios, furniture, diesel engines, cars, machine tools, gages, and dies need many different skills to do their jobs well.

The need for assemblers and their skills depends on the kind of product being made, its design, its quality, and its production volume. Where the assembly is done by hand, highly skilled workers are needed, Fig. 63-5. On the other hand, automatic assembly machines are now being used for many *high-volume products* (those made in very large numbers). Thus the only kind of worker needed is one to *supervise* (watch over and check on) the machines.

For *mechanical assembly* (done by machines), the skills needed depend on how well the parts must fit into the assembly. In *custom-fit assembly*, each part is finished to the right size and shape by hand. In this way, it will always fit its matching part, Fig. 63-6. Here again, highly skilled workers are needed.

Assemblies with *complete workpiece interchangeability* are those where any pair of matching parts will fit and make the product work. Here the assembler needs much less skill.

In *selective-fit assembly*, matching sizes of parts are made larger than they often need to be in order to fit together. It is cheaper to make them this way. For instance, two parts that will fit together can be assembled, but neither of those two parts will fit with a third part. Thus the parts must be measured and matched to get the fit that will work. Here the assembler needs more skill than one who is working on in-

Fig. 63-5. These highly skilled workers are assembling transistors.

terchangeable assemblies, but not as much skill as one who is doing custom fitting.

In the assembly of most high-volume products, each assembler usually does a simple job over and over again. Very little skill is needed for jobs like these (except for custom-fit assembly). As the assembler does his job over and over, he gets very good at positioning and fastening the parts and assemblies. Some workers get dissatisfied because there is no challenge in such a job.

When liquids and gases are assembled, the worker is usually operating a control panel of switches and valves. The control panel operates the machines that proportion, mix, and transport the liquids and gases.

In some industries like electronics, there are many assembly jobs that need a steady hand but not much physical strength. Women can often do some of these jobs better than men can, Fig. 63-7.

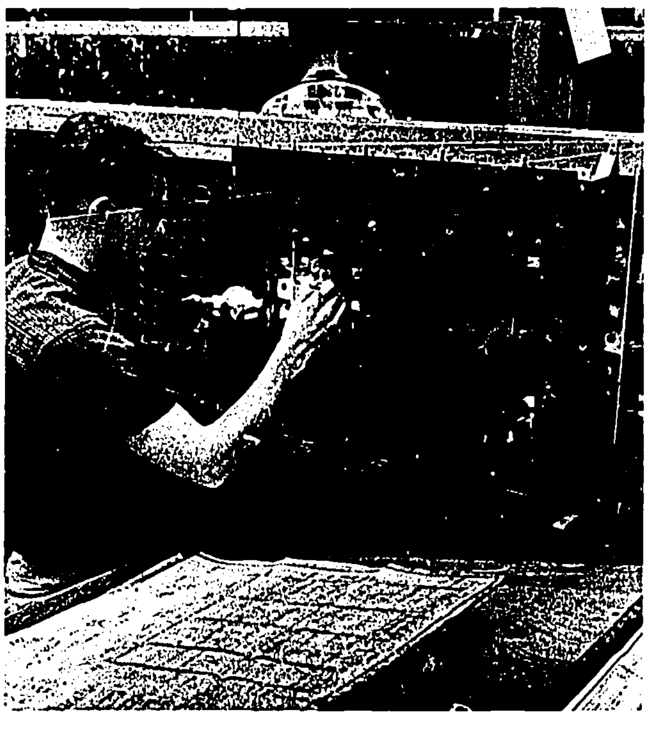


Fig. 63-6. An alarm circuit is wired by hand into each of these frames in a custom-fit assembly of central office switching equipment.

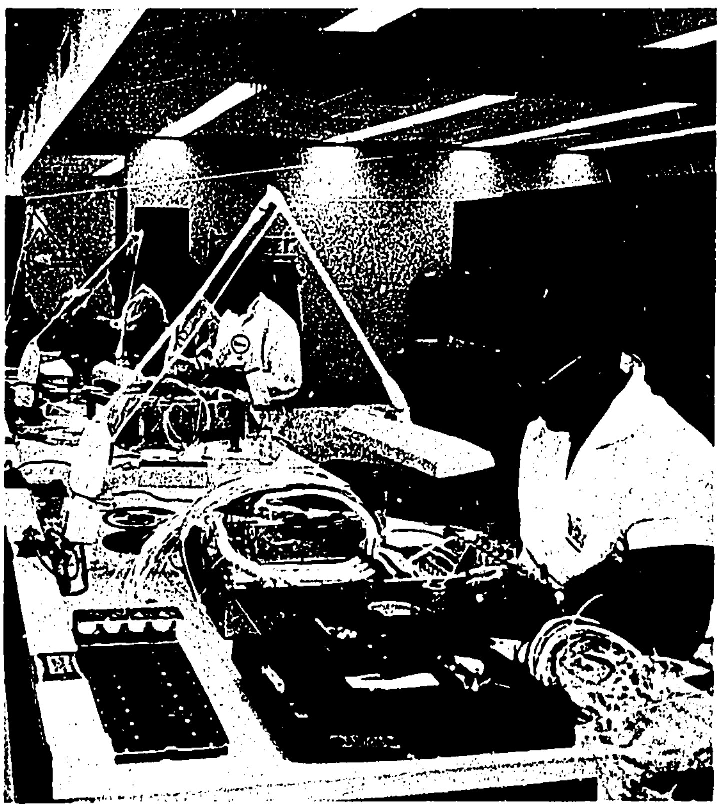


Fig. 63-7. Assembly-line workers are shown here in an electronics assembly area.

Summary

Mixing, coating, bonding, and mechanical fastening are used a great deal to make subassemblies into more complex products. Bonding and mechanical fastening are used very often.

Assembly can be done by the lot or batch, or it can be continuous. Lot or batch assembly makes fewer products at higher costs per unit. Continuous (line) assembly makes more products at lower costs per unit.

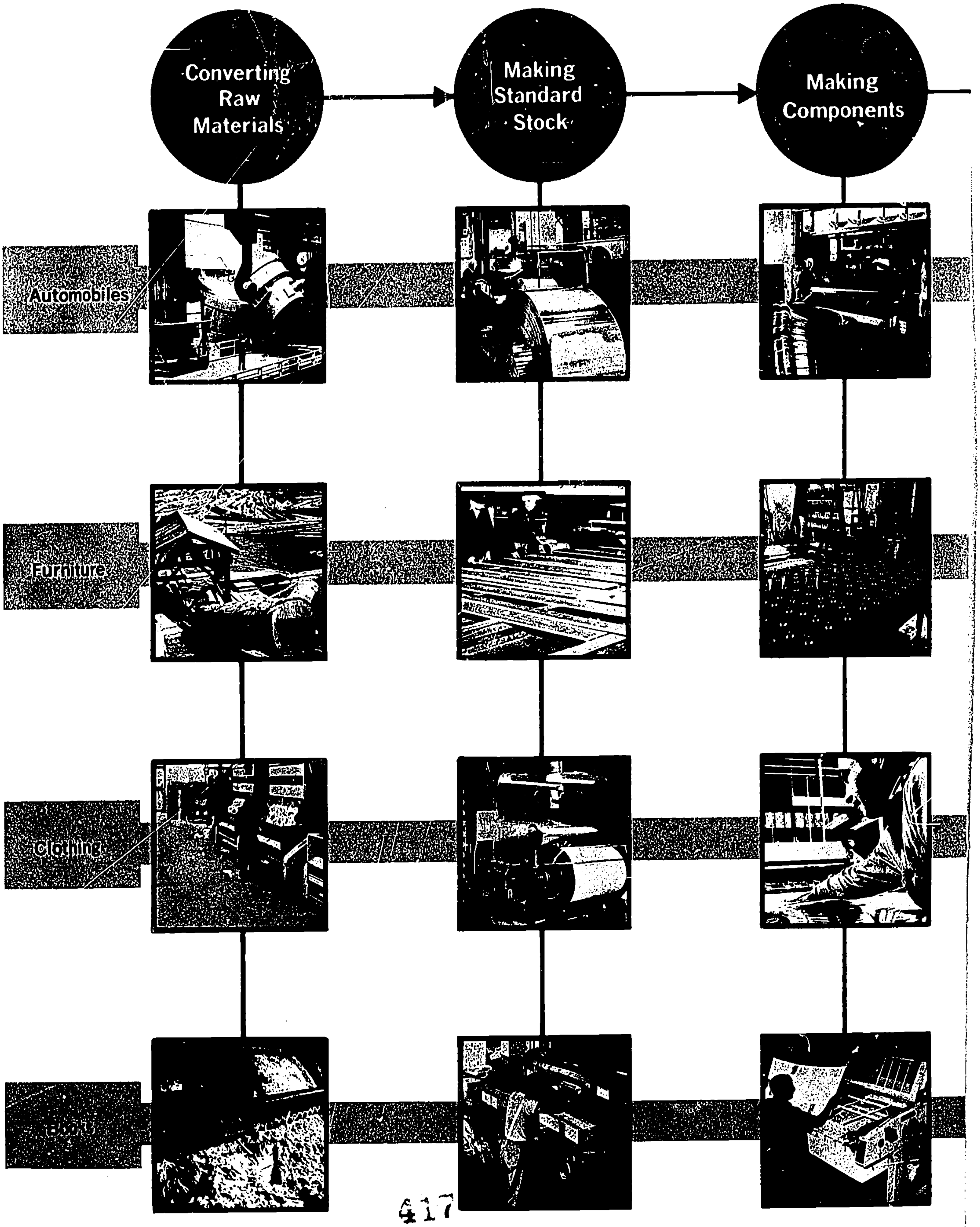
The assembly-line worker must position and fasten parts and subassemblies. In some jobs he must be highly skilled. In others, he can be less skilled. In some jobs, the worker has to do the same thing over and over again. Some people like to do this kind of work, while others do not.

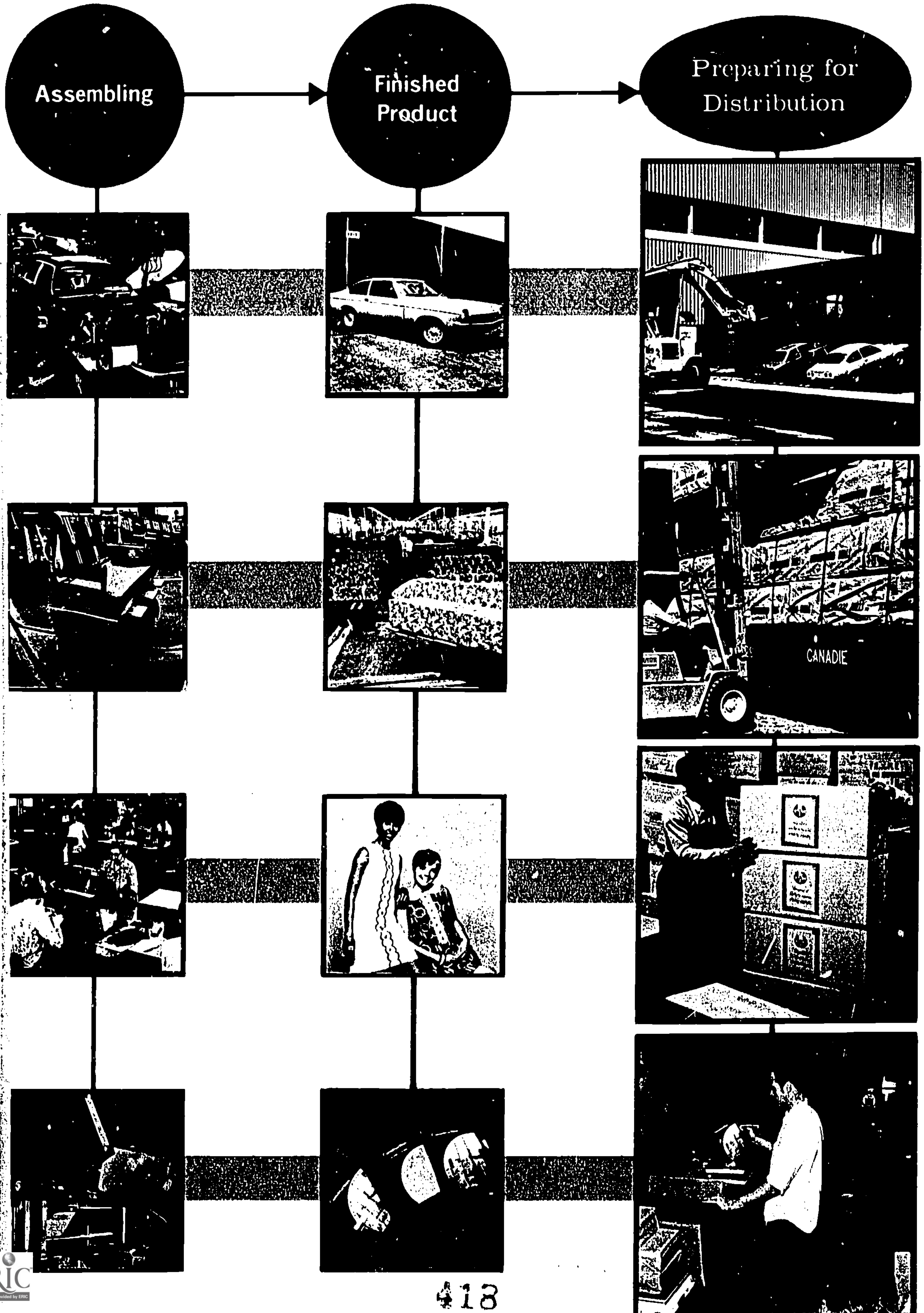
Terms to Know

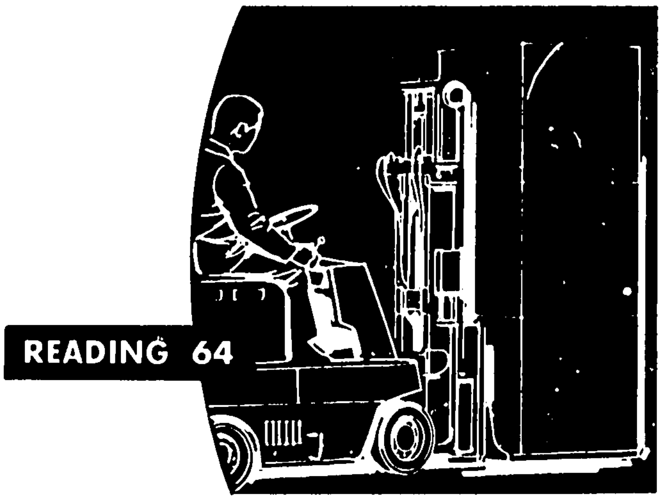
components
subassemblies
combining
mixing
coating
bonding
mechanical fastening
complex
assembly
quality control
defect
defective
batch (lot) assembly
continuous assembly
seasonal
production volume
continuous assembly line
position
fasten
mix
product distribution
assembler
high-volume products
supervise
mechanical assembly
custom-fit assembly
complete workpiece interchangeability
selective-fit assembly

Think About It!

1. Can you identify products in your home or school that were made by
   a. batch (lot) assembly?
   b. continuous assembly?
2. Why do you suppose that women can do some assembly jobs better than men can?


Converting Raw Materials
Making Standard Stock
Making Components
Automobiles
Furniture
Clothing


Assembling
Finished Product
Preparing for Distribution
CANADIE



READING 64

Preparing for Distribution

There are five stages in production technology. They are (1) *preparing raw materials*, (2) *making standard stock*, (3) *making components*, (4) *combining components*, and (5) *preparing for distribution*. In your readings so far, you have learned about the first four of these. In this reading, you will learn about the fifth one: how to get products ready for *distribution* (ways to get them to customers).

From Raw Materials to Product

We get raw materials in a number of ways from the natural world around us. They are then *prepared* (gotten ready) and *processed* (changed) into standard stock. *Components* (parts) and one-piece products are then made from standard stock in two ways. These are (1) *forming* and (2) *separating*. After they have been formed and separated, parts are then *assembled* (combined with other parts) into *subassemblies* (small units to be made into larger units) or finished products.

A finished product is then prepared for *distribution*. This is done by *packaging* it (putting it in some kind of container). The packaged product then goes to *distributors* (those who ship it). From there it goes to *wholesalers* (those who buy it in large quantities to sell to retailers). From there it goes to *retailers* (those who sell it in smaller quantities to the public). At last, the product gets to the *consumers* (those who buy it for their personal use).

For instance, tires may be sold to a car manufacturer, a tire distributor, a service station, a department store, a car accessories shop, or a car repair shop. All these tires will finally get to the consumer, the "man on the street" who buys the tires for his car.

Preparing to Distribute Products

Before products are ready to be shipped, they must be *protected*, *labeled*, and *stored*. Products must be *protected* so that they are "new" when they get to the customer. Packages, crates, cartons, packing, waterproofing, and insulation are all used to protect products from damage, Fig. 64-1. Products can be damaged by rough handling, by moisture, or by bad weather, Fig. 64-2.

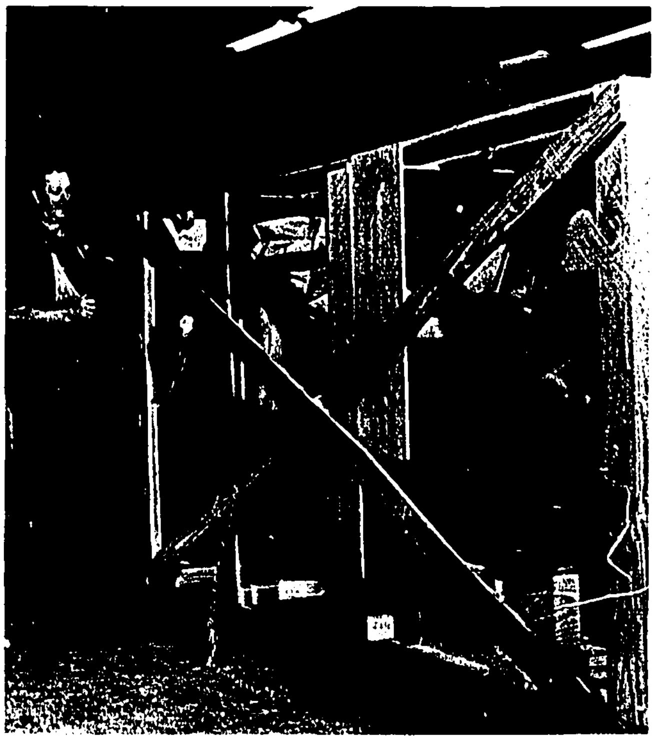


Fig. 64-1. This metalworking lathe is almost ready for shipping. The crate will protect the lathe from damage and make it easier to handle.

Products must be *labeled* so that they can be *identified* (recognized) by those who buy them, Fig. 64-3. Think what it would be like if several different products were packed in unlabeled cans of the same size and shape. You could not tell them apart. Labels and other kinds of markings on products must be read by the shipper, the wholesaler, the retailer, and the customer.

Fig. 64-2. Some products are put in cartons to protect them while they are being shipped. Otherwise, they might be damaged by rough handling, moisture, or bad weather.

Products must often be stored until it is time to ship them. They are usually put together in lots that are easy to handle, Fig. 64-4. For instance, you buy a tube of toothpaste in a small box. It is much cheaper, though, to handle and store these small boxes of toothpaste if they have been packed in cartons that hold dozens of them.

The labels, cans, boxes, paper, and other materials used to pack parts and products are themselves products. For instance, a food-processing plant may buy glass jars from a bottle-making plant, cartons from a paper-products plant, and labels from a printing shop.

Handling Materials

To get parts and products ready to ship, they must be handled and moved, either by

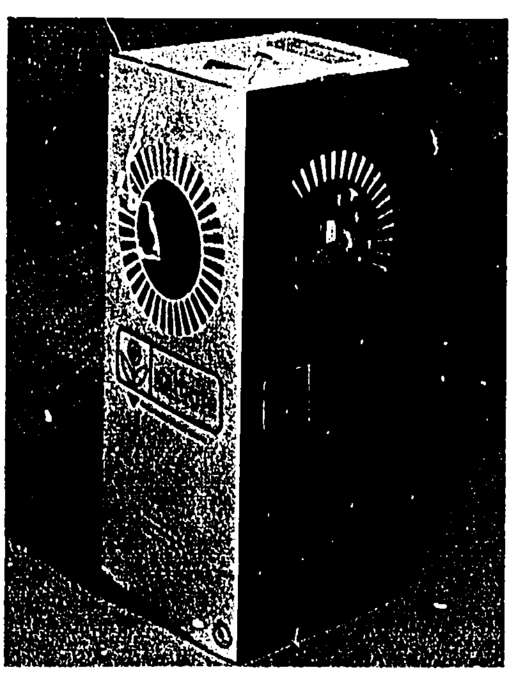


Fig. 64-3. This package is labeled so that the customer can read it easily. Inside this box are parts for four different products.

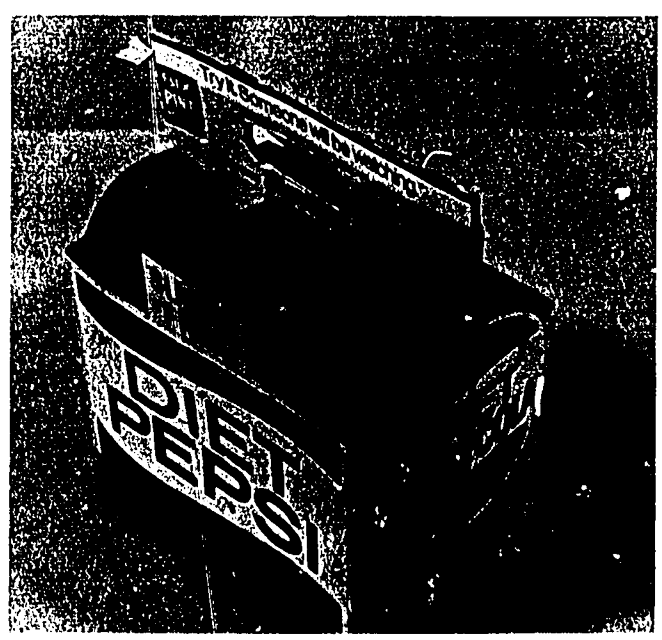


Fig. 64-4. Some cartons are used to place products into convenient lots. This carton can hold six 16-ounce soft drink bottles.

men or by machines. It has become such a *complex* (complicated) job to handle and move parts and products that special techniques have been devised to do the work.

Very large numbers of products now come off assembly lines in automated plants. It is a big job just to move them so that others can come off the lines. Production planning and control men must make plans to route, handle, stack, sort, store, and count these products. There are conveyor belts, fork-lift machines, and *pallets* (movable wooden platforms) to move large and small products, both before and after packing, Fig. 64-5. The production planner must know how to use these moving tools and machines so that products can be packed, labeled, stored, and loaded for shipment as quickly and as cheaply as possible, Fig. 64-6.

Fig. 64-5. American-made products are being unloaded at a foreign seaport on movable wood platforms called *skids*. A skid can handle and move 36 boxes at once.

To get a product ready to ship, it must be packaged. Most products must be placed in cans, bags, sacks, boxes, or similar containers, Fig. 64-7. Some products are crated, Fig. 64-1. Heavy products are often fastened to pallets or *skids* (large movable wooden platforms), Figs. 64-1 and 64-5. Special packing is often used inside the containers. All containers must be labeled so that anyone who handles them will know what product is inside them.

After parts and products have been packed and labeled, most plants move them to a *warehouse* (place where products are

Fig. 64-6. The tires on the forklift truck on the right have been wrapped, labeled, and put onto pallets where they can be moved easily. The tires in the background have also been labeled and put onto pallets, but they have been stored until it is time to ship them.

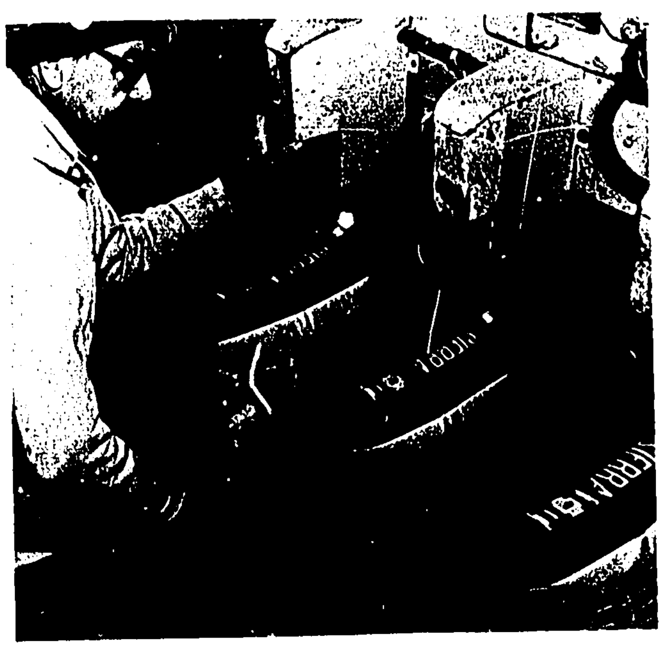


Fig. 64-7. Portland cement comes off the end of the assembly line in self-sealing, 90-pound sacks. The sacks are labeled and ready to be shipped.

stored until it is time to ship them). From the warehouse, products are loaded onto trucks or railroad cars, and then shipped. You can see that a plant cannot be run well without good techniques for handling materials.

Packages and Packaging

Products are usually put inside a *package*. The package is often as important as the product it contains.

The package itself is a product. It has been designed and manufactured. Its production must be planned and controlled. Raw materials or standard stock to make it must be moved in. During its production, there must be *quality control* (those actions needed to make sure that the package meets specifications). After production, the package must be shipped to waiting customers. These customers are often other manufacturers who then fill the package with another product.

Some kinds of bottles, cans, and boxes can be made in standard sizes and shapes since they are always needed. Other containers must be made for a certain product. For instance, the manufacturer of a liquid *detergent* (soap) to be used to wash dishes may want the product packaged in a plastic bottle that has a special shape. It may take as much special knowledge and skill to design this bottle as it takes to design a saucepan or a TV cabinet.

Containers are made from many different materials in many sizes and shapes. There are metal cans, foil wrappers, cardboard boxes, wooden crates, bags made of plastic film, glass bottles and jars, woven bags and sacks, and many other materials and shapes, Figs. 64-8 and 64-9.

There are many plants that manufacture standard stock used to package products. For instance, *corrugated cardboard* (a standard stock) is made from trees (a raw material) by many refining and converting plants. This standard stock would then be sold to a manufacturer of cartons. In his

Fig. 64-8. Packages come in all sizes, shapes, and materials. The kind of package often depends on the form of the product.

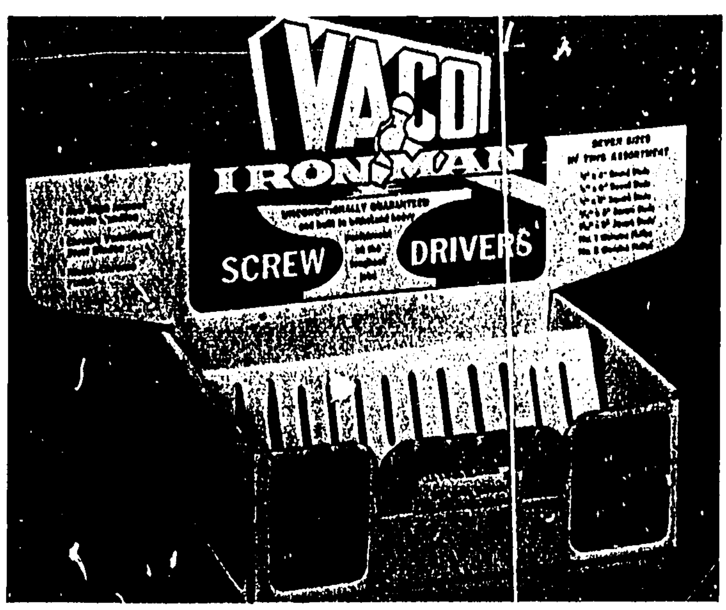


Fig. 64-9. Cardboard boxes come in many sizes and shapes. This box not only holds the products but also serves as the display unit.

plant, shearing and grooving would take place. Printing might also be done to put the brand name of the customer on the cartons. Next, large quantities of cutout cartons might be shipped to a food processor. At his plant, each carton would be folded and the bottom flaps bonded, probably with staples. Then each carton would be filled with cans of food, and the top flaps sealed shut.

In a large plant, all these packing jobs might be done by machines. In small plants, men might do these jobs by hand.

There are many plants that manufacture standard stock and process raw materials into all kinds of containers. Besides these, there is another group of plants that make machines that fill and seal packages, Fig. 64-7.

Summary

Preparing products and parts to be distributed is the last of the five stages of production technology. It includes moving, packing, protecting, and storing the products. It starts at the end of the assembly line. It ends when the products are shipped to customers.

Before a product is ready to be shipped, it must be packaged to protect it, to label it, and to store it. The product must also be moved and handled after it has been packaged. Special techniques to handle materials have now been devised so that products can be prepared for shipment as quickly and cheaply as possible.

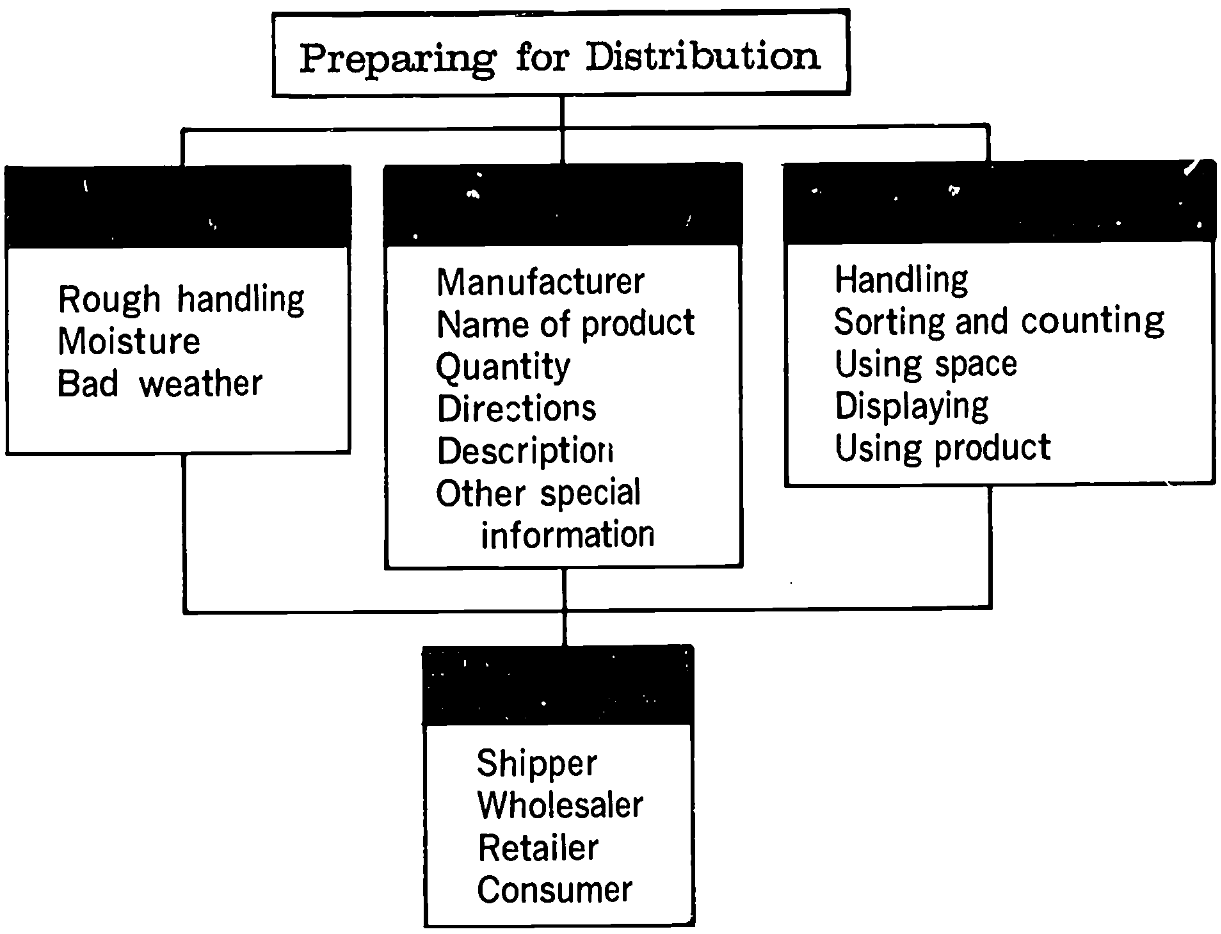
The package itself is a product. Like the product it contains, it must be planned, produced from standard stock, labeled, stored, and shipped to customers.

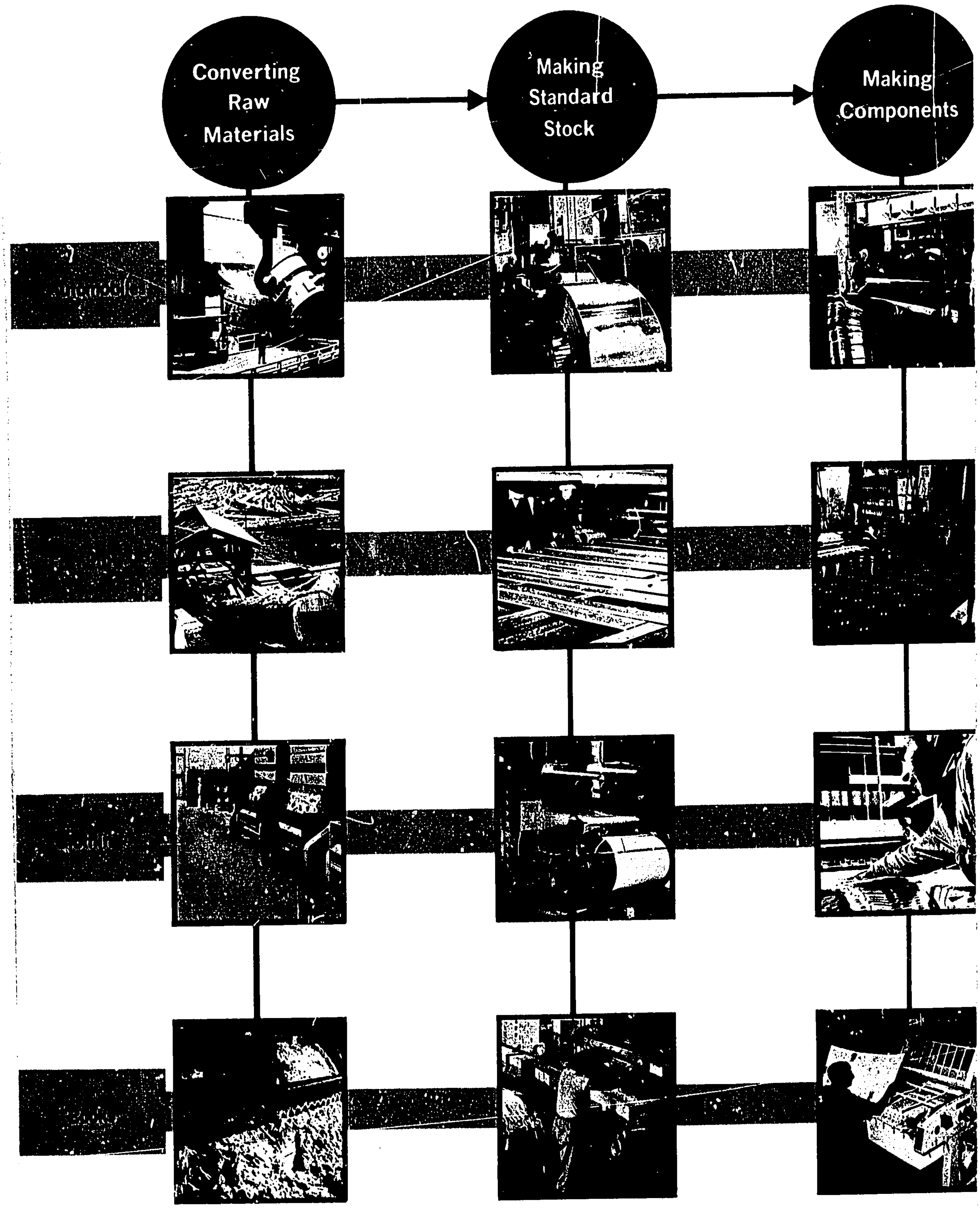
Terms to Know

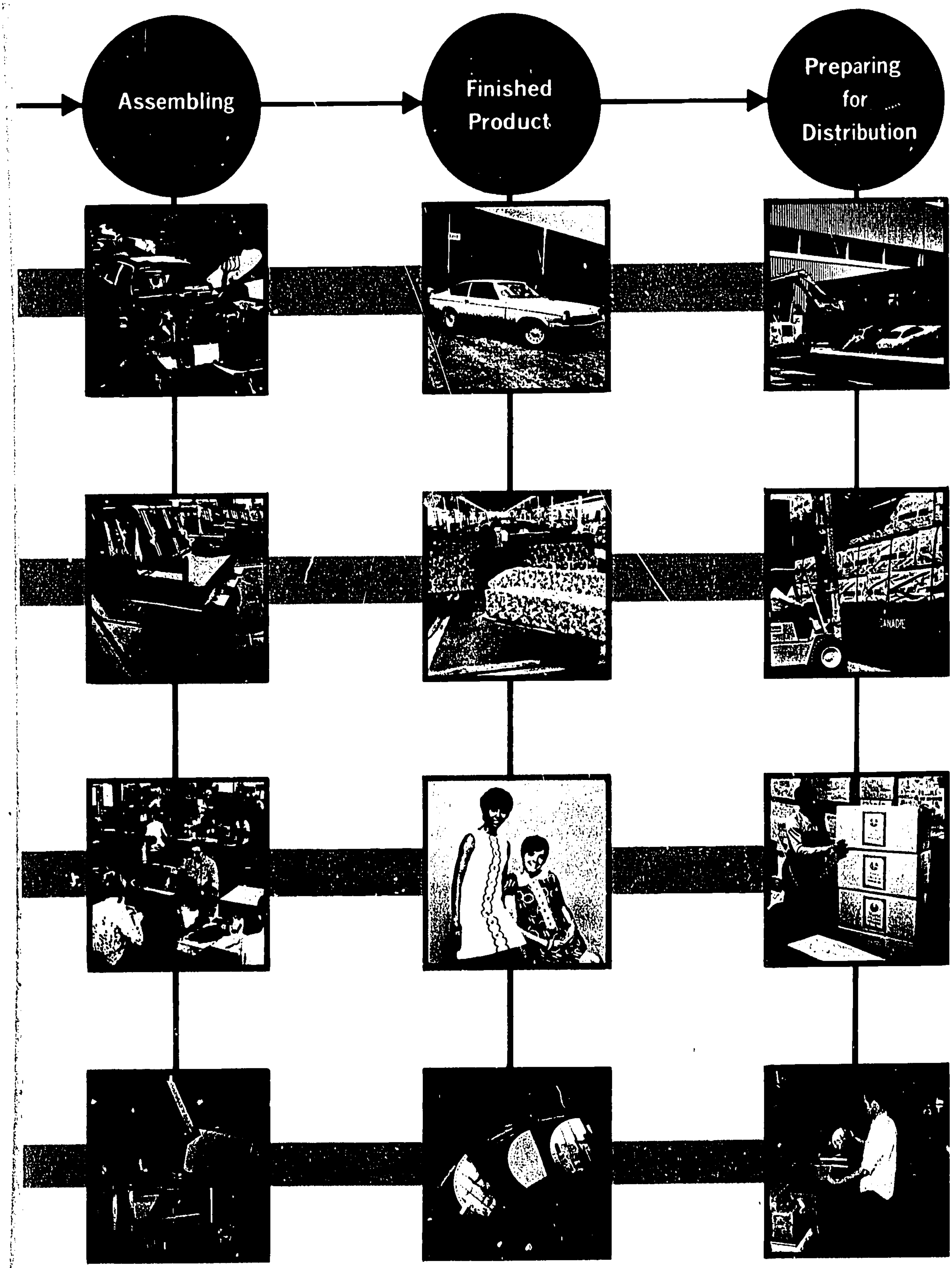
distribution	protected
processed	labeled
components	stored
forming	identified
separating	complex
assembled	pallets
subassemblies	skids
prepared	warehouse
packaging	quality control
distributors	detergent
wholesalers	corrugated cardboard
retailers	package
consumers	

Think About It!

1. Look in the kitchen at home and choose what in your opinion is the product with the most attractive *package*.
   a. Why is this package more attractive than other packages in the kitchen?
   b. Briefly describe the making of this package from the raw material to the finished product.
2. You use many products during a single day. Of the products you used today, which went through the most *complex distribution* stage of manufacturing? Briefly describe the distribution steps of this product.


Preparing for Distribution
Rough handling
Moisture
Bad weather
Manufacturer
Name of product
Quantity
Directions
Description
Other special information
Handling
Sorting and counting
Using space
Displaying
Using product
Shipper
Wholesaler
Retailer
Consumer


Converting Raw Materials
Making Standard Stock
Making Components


Assembling
Finished Product
Preparing for Distribution

READING 65

Servicing Manufactured Products

After the customer gets a product, service on it is often needed. *Servicing* is done (1) to *install* a product, (2) to *maintain* it, (3) to *repair* it, or (4) to *alter* it to fit some special need. In this reading, you will learn about some of these kinds of services. Servicing is sometimes called *postprocessing.*

Durable and Nondurable Products

There are two major kinds of manufactured products. They are (1) *durable* and (2) *nondurable.* Nondurable products are those that do not last three years. Durable ones are those that last three years or more. Food and clothing are nondurable products. So are light bulbs, pencils, and floor wax. Farm trucks, stoves, and pianos are durable products. They will last three years or longer. It is the durable products that need the most service. Nondurable products may need service, but not as often or as much as durable ones do.

Installing the Product

Most services make the product last longer and increase its value. *Installing* must be done, though, *before,* the customer can begin to use his new product. Many new products must be set in place and fixed there *permanently* (so they can't be moved), Fig. 65-1. Some must be attached to a utility system: for example, plumbing or wiring. The service of putting products in place so they can be used is called *installing.* For instance, some telephone company workers install phones in people's homes. Others install switchboards in offices, Fig. 65-2. If you add seat covers to your car, you are installing one product (the seat covers) inside another (the car).

Maintaining the Product

To *maintain* something means to keep it in good shape or in good working order so that it can be used. *Maintenance services* are those that keep a product useful. Lubricating and tuning up a car are maintenance services, Fig. 65-3. So are washing and waxing it. In fact, most washing jobs are a way of keeping a product useful. Shirts, kitchen floors, and coffee cups must all be maintained by washing them.

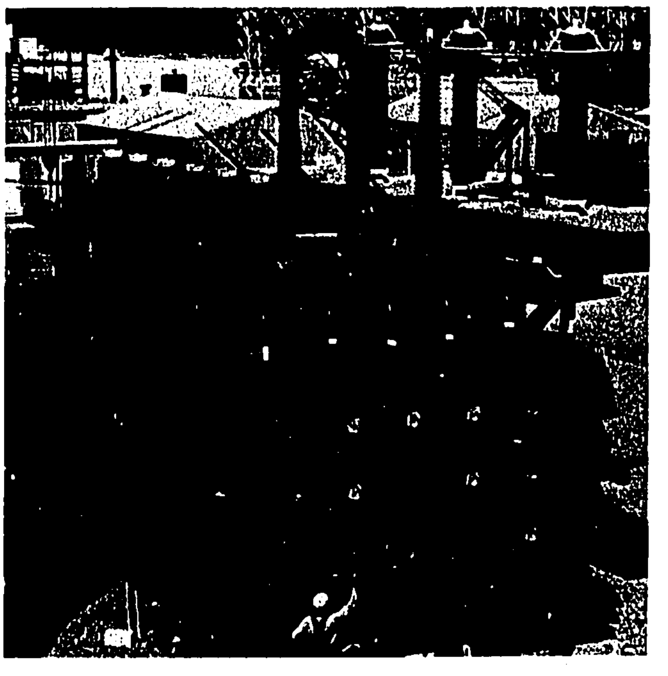


Fig. 65-1. Some manufactured products are very large. The manufacturer has installed this transformer and is now filling it with oil.

Some maintenance jobs are done by the *consumers* (those who use the product). Other maintenance jobs are done by special-service firms. Commercial laundries and dry cleaners are good examples.

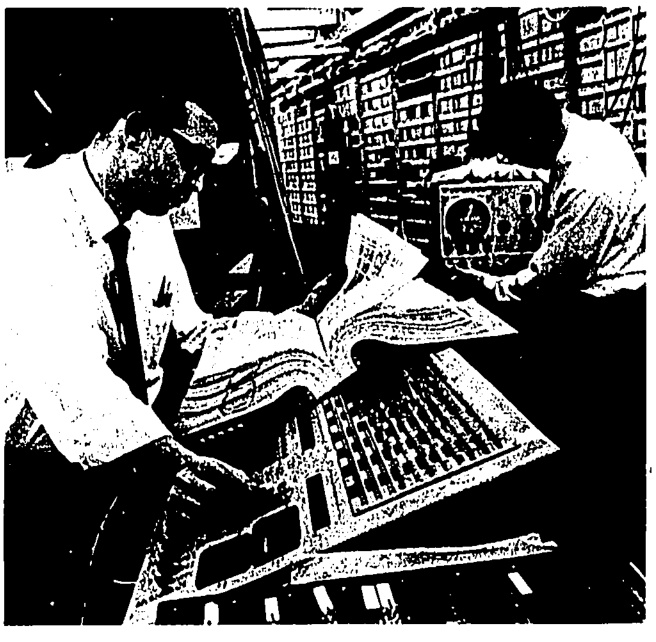


Fig. 65-2. Service is done by many people. These two men are testing electronic telephone switching equipment after it has been installed.

Fig. 65-3. Your family car needs maintenance to make sure it runs well and to cut down wear on its parts.

To *repair* a product, you would fix it, mend it, or replace worn out or *defective* (poorly made) parts in it, Fig. 65-4. For instance, a defective master brake cylinder in a car would be repaired by putting in a whole new unit. This was not true ten years ago. At that time the car owner might have bought just a new plunger to replace the one in the brake cylinder that was worn out. In the last ten years, the cost of making most *subassemblies* (small units that combine into larger units) has been *reduced* (cut down). Thus it is now cheaper to replace the whole unit, rather than take it apart to replace a single part.

There are three major steps you should take to repair a product. *First*, you must find out what is wrong with it. This is called *diagnosis*. *Second*, you must make the repairs you find are needed. *Third*, after you have repaired the product, you must test it to make sure it is working as it should.

Some repairs are done in the same way as the product is made. For instance, if a dinette chair is missing a leg cap, it can be repaired by just replacing the cap. A baseball with broken stitches can be repaired by just restitching the seam. Thus the basic process used by the manufacturer is done over again, but at a different time and place.

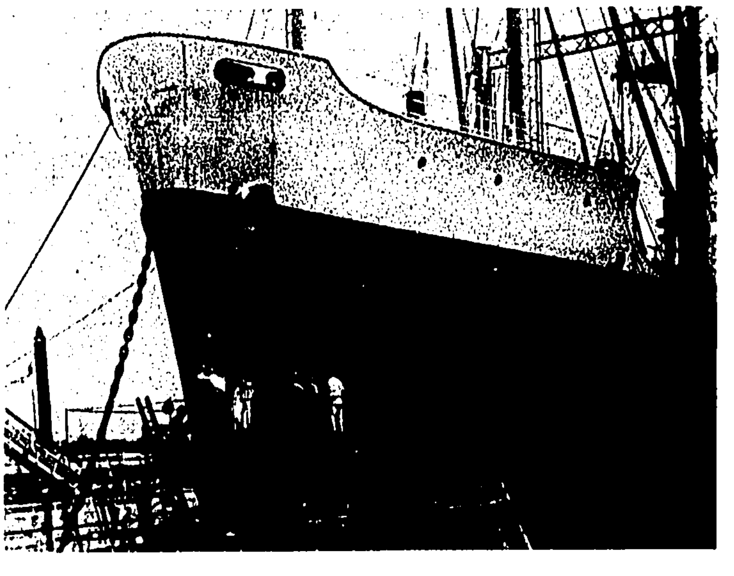


Fig. 65-4. This huge seagoing freighter is in dry-dock for repairs.

Other repairs are *not* done in the same way as the product is made. For instance, putting a patch on an inner tube is not like making the tube at all. It is the maker of the tire repair kit, not the maker of the inner tube, who has developed the knowledge of how to put the patch on the tube.

Altering

When you *alter* a product, you change it so that it does not look or work exactly as it did when it was first made, Fig. 65-5. For instance, if a longer cord is put on your home phone, it has been altered. If your mother lengthens or shortens the sleeves on your jacket, she has altered them. If your car is *customized* by changing its body shape or by boring out the engine, it has been altered.

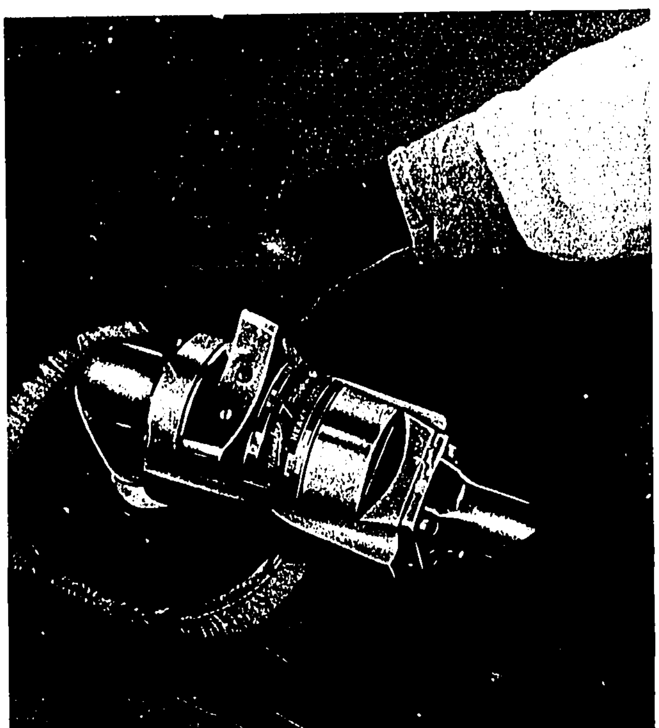


Fig. 65-5. This portable power tool is being used to buff the surface of an auto body that was recently repaired.

Service Workers

Service is done by many people, Fig. 65-2. A manufacturer may install a large machine in the plant of another manufacturer, Fig. 65-1. This machine may be maintained and repaired by the new owner, by the firm that made it, or by another firm that specializes in this kind of service. The machine may later be altered by the original maker or by the new owner.

Products like cars that need special tools and skills are often serviced by men or firms that specialize in automotive care. Sometimes, a car can be serviced by the owner himself. Such an "extra" as an air conditioner may be installed in a car by an auto dealer, by an auto air-conditioning firm, or by the owner as a "do-it-yourself" job. If the car is to be *customized,* it is often done by someone who does this special service.

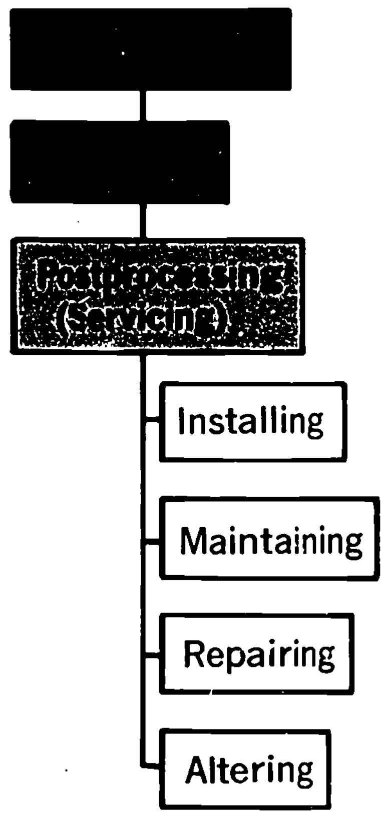
In the near future, the need for service workers will continue to grow. For those workers who service manufactured products, such a need will last for some time yet. Most manufacturers would like to cut down the amount of product service, though. They want to improve their products so that they won't need much service after the customer buys them. Today some products have plug-in units that can be replaced by the customer himself. You can see that if products are improved in this way, product service as we know it today will be quite different in the future.

Summary

Servicing (postprocessing) is done on manufactured products to make them last longer and to increase their value. Products are serviced by people who install, maintain, repair, and alter them. Products may be serviced by the manufacturer, by special-service firms, or by the customer himself.

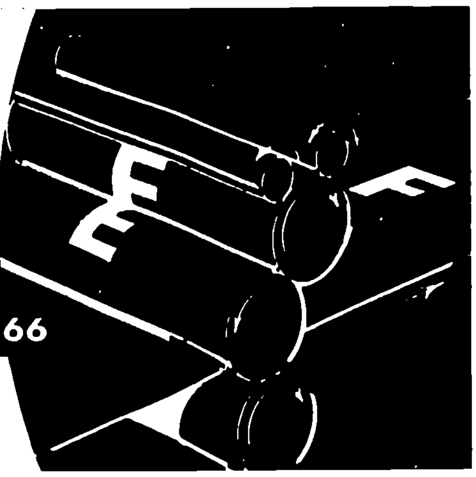
Terms to Know

servicing	permanent
install	maintenance services
maintain	consumers
repair	defective
alter	subassemblies
postprocessing	reduced
durable products	diagnosis
nondurable products	customized



Think About It!

1. Visit a neighborhood hardware store and identify:
   a. five products that need servicing *before* they can be used; and
   b. five products that need *no* servicing before they can be used.
2. Look at the advertisements in a magazine or newspaper and list:
   a. five *durable* products; and
   b. five *nondurable* products.



Story of Printed Products

You are quite familiar with *printed products*. You have seen and used books, newspapers, magazines, posters, catalogues, packages, and brochures. You have also seen decals, lettering on bottles and cans, playing cards, maps, woodgrain for paneling and furniture, wallpaper, paper money, business forms, and calendars. These too are printed products. In this reading, you will learn something about the products of printing, the techniques used in printing, the people who work in the printing and publishing industry, and the industry itself.

Printed Products and the Economy

In the United States, over one billion books and 25 billion newspapers are printed each year. More than one million people work in the printing and publishing industry. The *volume* (number of products made) and the dollar value of printed products keep growing each year. Employment also keeps growing. Nearly one-third of the people in the industry work as production people. The other two-thirds work in jobs that *support* (help) production. The printing and publishing industry ranks very high among industries in the dollar amount of products sold. It ranks high also in the dollar amount of payroll it pays out.

Kinds of Printed Products

All printed products start with an idea. There may be a need for a new history book, a new box for your favorite soap, a more up-to-date road map, or a new advertising poster.

There are five major kinds of printed products. They are (1) *newspapers*, (2) *magazines*, (3) *books*, (4) *commercial printing*, and (5) *converted products*. *Newspapers* are very familiar to you. *Magazines* are *published* (printed) at specific times, like once every week or once every month. As a student, you are quite familiar with *books*. *Commercial printing* includes nearly all of the products that are not one of the first three kinds. For instance, there are advertising posters, wrapping paper, business forms, tickets, calendars, decals, legal forms, greeting cards, and playing cards. *Converted products* include packages and special finishes on paper.

Kinds of Printing Processes

There are four basic kinds of printing processes. They are (1) *relief printing*, (2) *planographic printing*, (3) *intaglio printing*, and (4) *screen stencil printing*. Some of these print only one kind of product. Others can be used to print many different sizes and shapes on many different kinds of materials.

Relief Printing

Relief printing is done by placing ink on a raised surface and then pressing the inked

surface against paper, Fig. 66-1. The ink comes off on the paper in the shape of the raised image. An example of relief printing is a finger print. If an inked finger is pressed against a piece of paper, only the high spots put ink on the paper. The low spots of the finger do not touch the paper and will not print. Some products made by relief printing are newspapers, packaging materials, advertising pamphlets, and catalogues. Some relief printing processes are *letterpress printing, flexographic printing,* and *letterset printing.* The machines used in relief printing range from small platen presses that print letterheads to huge cylinder presses that print newspapers by the millions.

Planographic Printing

In *planographic printing,* both the image to be printed and the surface in which the image is cut are on the same *plane* (flat surface). The most common planographic printing process is *lithographic printing. Lithography* comes from a Greek word that means *writing on stone.* Early lithographic printing took place in just that way. With a greasy crayon, drawings were made on a flat *absorbent* stone (one that soaks up liquids). The water ran off the greasy drawings but soaked into the stone where there was no grease. Next, ink was put onto the stone. The ink ran off the wet stone but soaked into the greasy drawings. When paper was pressed against the stone, the ink in the greasy spots came off the stone onto the paper in the image of the drawings.

Today the process has been changed. Thin metal plates are used instead of the stone. The image to be printed is put onto the metal plate, Fig. 66-2. Then the plate is moistened and inked. The plate is then pressed against a rubber *blanket* (pad), and the image comes off the plate onto the pad. Paper is then pressed against the rubber pad, and the image comes off the

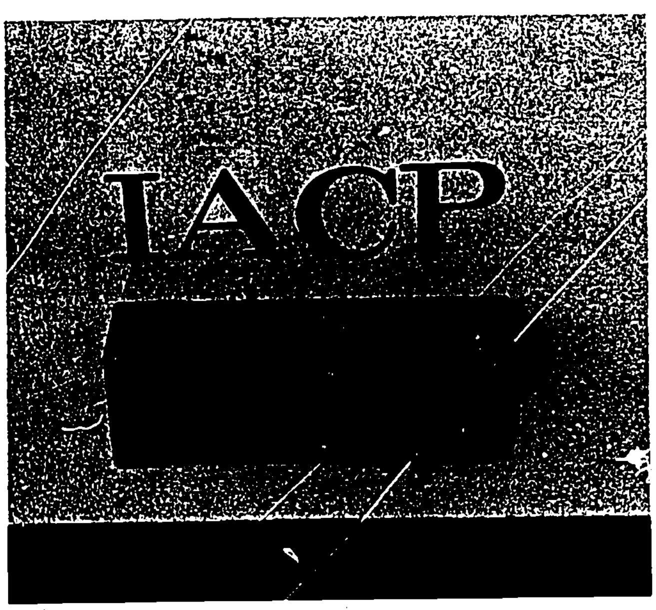


Fig. 66-1. These raised type letters can be used for relief printing. When they are inked and then pressed against paper, they will print IACP.

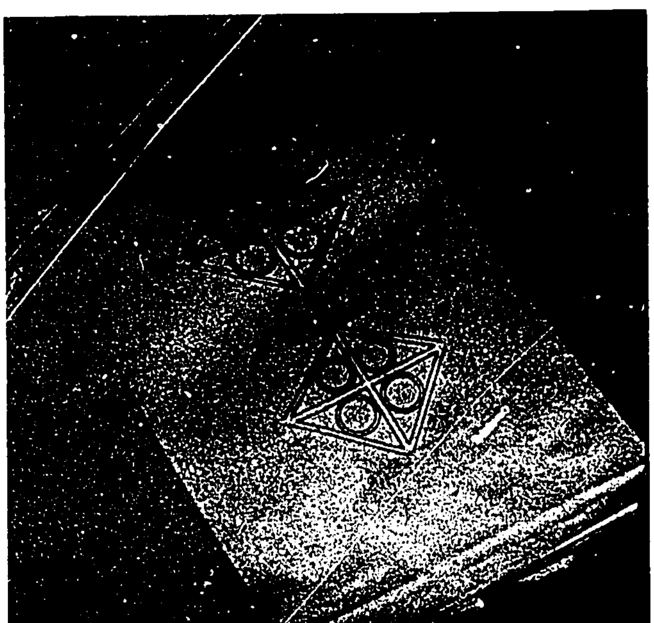


Fig. 66-2. An offset printing plate is made of a thick sheet of metal. The light and heavy inking depends on the contrast between the light and dark places on the plate.

pad onto the paper. See Fig. 66-3 for a sketch of this process. This is known as *offset lithography* because the image is offset from the metal plate to the rubber pad. Machines have been built that can print four colors at once and several thousand sheets an hour. Some of the products made by offset lithography are commercial advertising, folding cartons, books, magazines, and displays.

Intaglio Printing

Intaglio printing is the opposite of relief printing. The image to be printed is cut into a steel plate to form a *depressed* (sunken) image. Ink is then put into the depressed image. Then the *excess* (extra) ink is cleaned off the surface, but ink in the depressed image is left there. When paper is pressed hard against the plate, the ink is pulled from the depressed image onto the paper. The printed image comes out raised above the surface of the paper. See Fig. 66-4 for a sketch of this process. The main intaglio printing processes are *engraving* and *gravure printing*. Examples of products made by intaglio printing are wedding announcements, labels, letterheads, paper money, stock and bond certificates, and packaging materials. Intaglio printing is used a great deal for color printing and for work where large numbers of the printed product are needed.

Screen Stencil Printing

Many people call *screen stencil printing* silk-screen printing. Silk is not always used for the screen, though. The screen may be made from nylon, organdy, wire, or other materials. First, a stencil is made either by hand or by photography. Then the stencil is stuck to the screen, where it blocks out the places that will not be printed. Ink (or paint) is then placed on the screen and

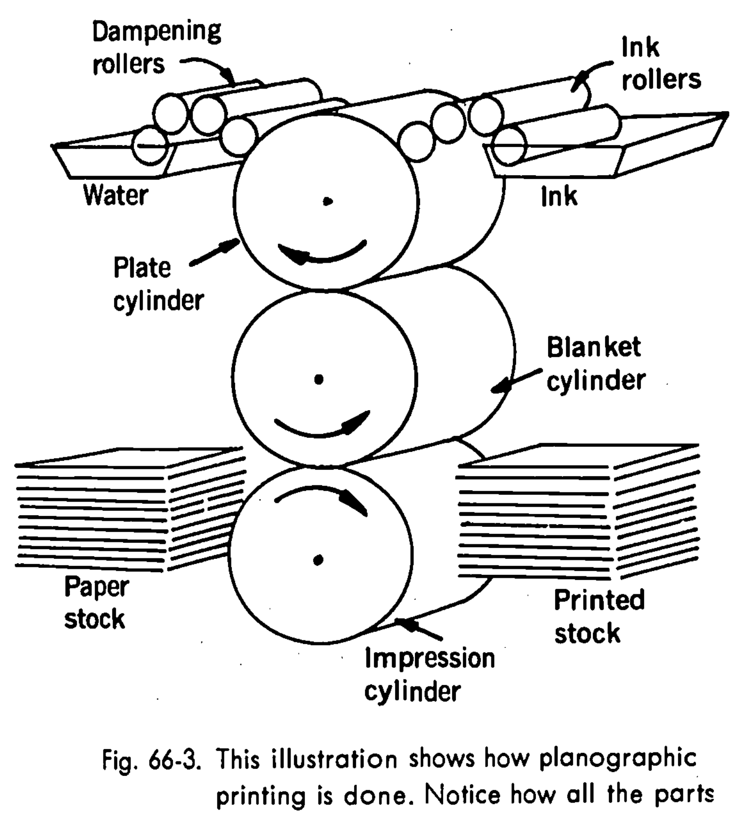


Fig. 66-3. This illustration shows how planographic printing is done. Notice how all the parts work together.

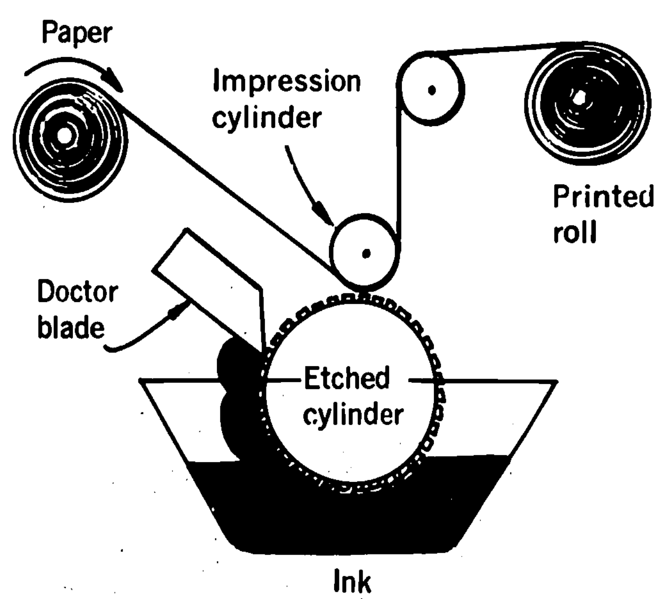


Fig. 66-4. Intaglio printing is graphically shown here. The doctor blade wipes the excess ink from the surface, but allows ink to remain in the depressed image areas where it will be transferred to the paper under pressure from the impression cylinder.

squeegeed across the screen. The ink passes through the holes in the screen not covered by the stencil. See Fig. 66-5 for a sketch of this process. Screen stencil printing is used to print words or designs on posters, signs, wallpaper, greeting cards, outdoor signs, dress goods, T-shirts, bottles, plastic containers, and many other products.

Six Steps in Printing

A printed product is made in a series of six steps. These are the steps:

1. creation of the *original* (first copy),
2. composition,
3. image preparation,
4. image transfer,
5. finishing, and
6. distribution.

The cost of the final printed product depends on how *complex* (complicated) these steps are.

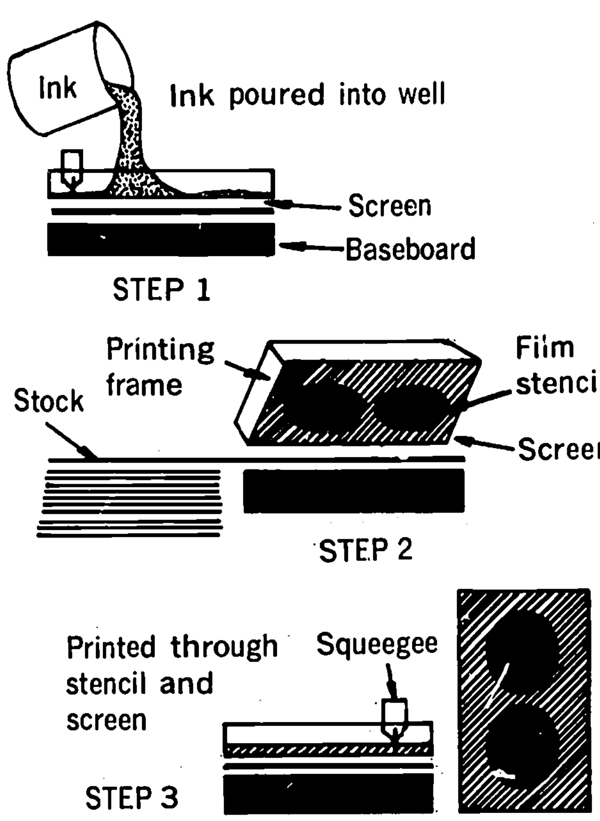


Fig. 66-5. Screen-stencil (silk-screen) printing is done in three different steps.

Creation of the Original

The first step in making a printed product is to put into *visible form* (what can be seen) all of the information to be printed. This is put into the form of either *text* or *illustrations*, Fig. 66-6. The text contains the words to be printed. The words are usually typewritten. Illustrations are the drawings and pictures used in the printing. Usually the customer gives a printer the text and illustrations. These are usually in the form of *paste-ups* (sketches of how the text and illustrations are supposed to be arranged on the printed page). See Fig. 66-7. Sometimes the printer gets the illustrations and the paste-ups ready for the customer.

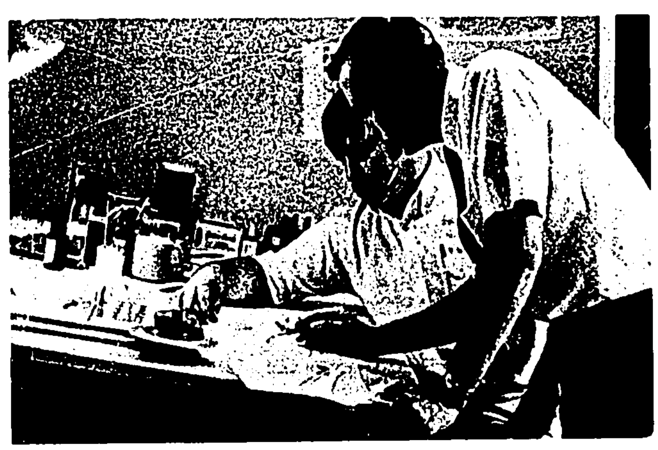


Fig. 66-6. The original (first copy) of a printed product is made by an artist and a copy editor. They make visual and written materials.

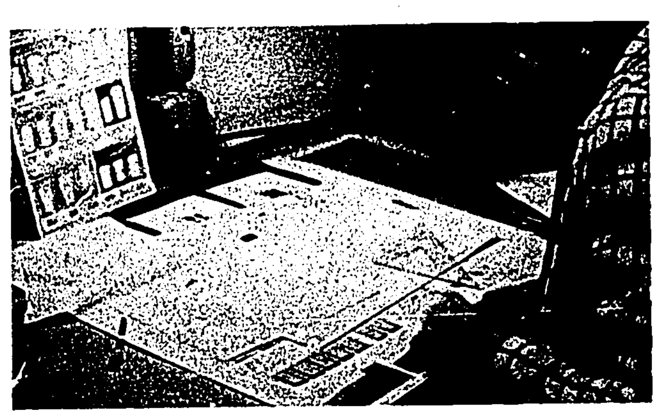


Fig. 66-7. Original copy is put into final form in a paste-up. This paste-up will be sent to the printer who makes the final camera copy.

Composition

Composition is the process of changing the original text into a final form to be printed. There are several ways to compose the text. The choice often depends on the printing process that will be used to print the product. The text can be composed by placing metal letters next to each other on a line of type, by typing the letters with a special typewriter, or by photographing them. Several of these ways have been made easier and more precise by the use of computers. Thousands of different sizes and shapes of letters can be used to compose texts. Each different shape of letter has a name and is referred to as a *type style* (for instance, roman, italic, gothic, old-style, etc.)

Image Preparation

Image carriers must be made for some texts and for all illustrations. An image carrier is the substance that holds the image to be printed, Fig. 66-8. For instance, the image carrier of a rubber stamp is the piece of rubber that makes the image on the piece of paper. Other kinds of image carriers are offset lithographic plates, stencils for screen stencil printing, photoengravings, stereotypes, and electrotypes.

Fig. 66-8. The image of the printed material is put onto a metal plate. The metal plate is the image carrier in this printing process.

Image Transfer

After the image carrier has been made, the image can now be put onto paper, Fig. 66-9. This step is most often called *presswork*. Each printing process uses a different kind of press to *transfer* the images (take them from the carrier and put them onto the paper). There are even several different kinds of presses used in some printing processes. For instance, platen presses, rotary presses, and cylinder presses are all used in letterpress printing.

Finishing

Finishing is done after the product has be printed. Some examples of finishing operations are cutting, folding, gathering, stapling, trimming, and binding.

Distribution

Printed products must be packaged and *distributed* (moved from where they were

Fig. 66-9. The metal plate (the image carrier) is put on the printing press. The printing press will transfer the inked image to the paper.

printed to where they will be used by the customer). See Fig. 66-10. The way they are packaged depends on the kind and number of the printed products.

People in Printing and Their Training

Many people work in the printing industry. They have very unusual names. For instance, there are compositors, lithographers, strippers, provers, platemakers, photoengravers, pressmen, cutters, and estimators. Most of these production workers get their training on the job, or in vocational and technical school programs. Many of the management and support workers get their training in colleges and universities, or from their work in the production jobs of the industry.

Summary

There are many different kinds of printed products. The five major kinds are (1) newspapers, (2) magazines, (3) books, (4) commercial printing, and (5) converted products. Printing is done by four processes. They are (1) relief printing, (2) planographic printing, (3) intaglio printing, and (4) screen stencil printing. The six steps in making printed products are (1) creation of the original, (2) composition, (3) image preparation, (4) image transfer, (5) finishing, and (6) distribution.

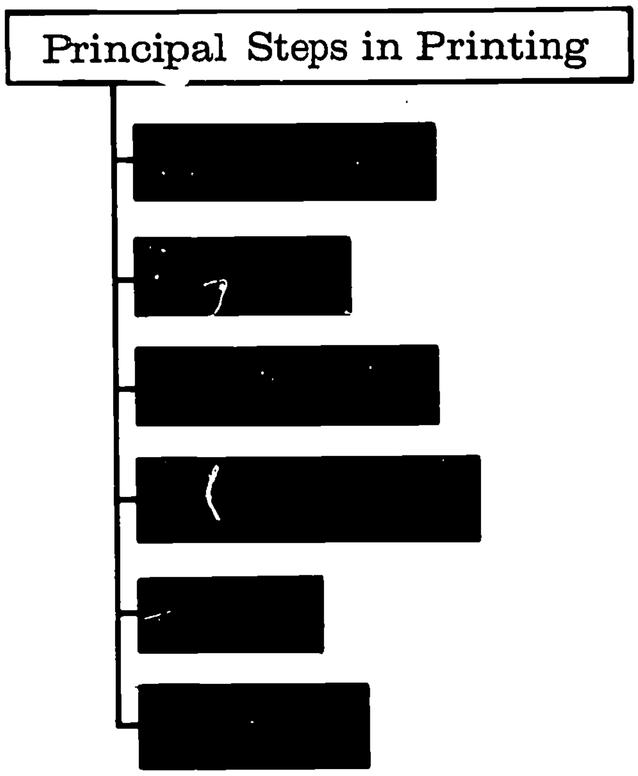
Fig. 66-10. Printed products are first printed and then packaged into cartons. The cartons are stacked in groups on a pallet before they are shipped to customers.

Terms to Know

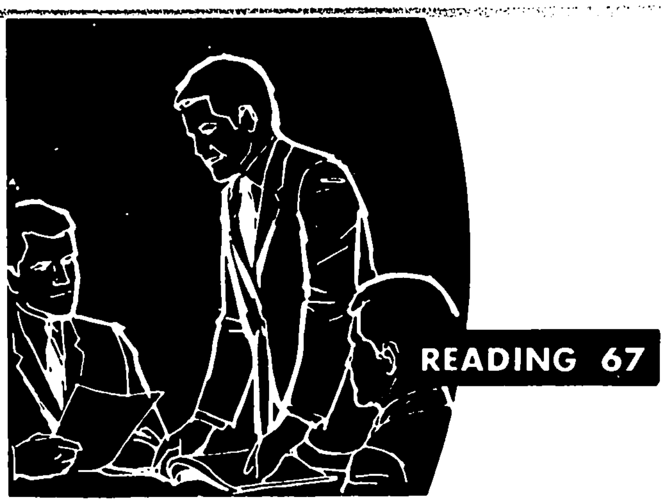
printed products
volume
support
newspapers
magazines
books
commercial printing
converted products
published
relief printing
planographic printing
intaglio printing
screen stencil printing
letterpress printing
flexographic printing
letterset printing
plane
lithographic printing
lithography
absorbent
blanket
offset lithography
depressed
excess
engraving
gravure printing
original
complex
visible form
text
illustrations
paste-ups
composition
type style
image carriers
presswork
transfer
finishing
distributed
printing

Think About It!

1. There is *printing* on nearly every product used by man today. Name ten products other than newspapers, books, and magazines that carry printed information.
2. There are four basic kinds of printing processes described in this reading. List the four processes, and under *each* process list *three* products used in your home that use each process.


Principal Steps in Printing

The Manufacturing Corporation



Most manufacturing firms in the United States are *organized* (set up) in one of three forms. They are (1) the *proprietorship,* (2) the *partnership,* and (3) the *corporation.* Last semester, you read a little bit about all three of these forms of business. In this reading and in those that follow, you will learn a little more about the corporation, the way it is started, and the way it is run.

To help you understand more about how to start a corporation, we will imagine that we are starting one to make and sell desk lamps. Of course, a corporation like this would probably make many other products as well.

Fig. 67-1. The modern corporation has grown out of business forms as old as the Middle Ages. One major difference between the modern corporation and the business organizations of hundreds of years ago is that laws now help people from losing money in case one person does something wrong.

In this reading, you will learn something of the history of modern corporations. You will learn a little about the laws that control the way they run. You will also learn a few of the terms that are used to talk about corporations.

Later on, after you have learned how to start and set up a corporation, you will plan, set up, and control one for making and selling desk lamps.

The History of Corporations

When was the first corporation set up? See Fig. 67-1. We do not know for sure, but there seems to have been a kind of corporation in the early days of Rome. Of course, it was quite different from the large ones we have today. The Roman corporation was set up to deal with education, not business, and it was not controlled by laws in those days.

During the Middle Ages, there weren't many corporations. In those days, the *proprietorship* (with a single owner) and the *partnership* (with two or more owners) were the common forms of business ownership.

A form of business organization once popular was the *joint-stock company.* This was a company set up and owned by a large group of men. Many important businesses (for instance, the British East India Company) were joint-stock companies. But the joint-stock company had one big drawback: the men who set up such a company could be made to pay its *debts* (bills) if their company could not make a *profit* (money leftover from sales after all bills have been paid).

438

The *modern corporation* goes back to 1598, when King James I of England began to *license* (give permission to act on their own) such groups as *guilds* (men with common interests, often merchants and craftsmen) and *boroughs* (towns set up to govern themselves). The attorney general for King James said that a corporation could *exist* (live) apart from the men who set it up. It could be thought of as a separate, living, *artificial person*. It could act on its own. It could make products and sell them on its own. It could make money and pay bills on its own. The men who set up such a corporation could not be made to pay its bills out of their own pockets.

You can see why people are more willing to join corporations than joint-stock companies. They are spending only what it costs to buy *shares of stock* (legal papers stating that they own a part, or *share*, of the business). In a joint-stock company, however, they could also be made to pay the company's debts if it didn't make any profits.

After 1800, the corporation became fairly widespread, especially in the United States. In this country, there were many laws passed to help corporations get started. In 1811, the state of New York passed the first *limited-liability law* (stating that the men who set up a corporation could not be made to pay its debts). By 1850, nearly every state had passed some kind of corporation law.

Corporations grew very fast in the 1800's. Before 1800, there were less than 250 corporations in this country. By 1900, the corporation was well on its way to becoming the most common form of business in the United States.

The Language of the Corporation

You should understand the language used to talk about the corporation, Fig. 67-2. Some of the terms that are used most often are *charter, entity, limited liability,* and *longevity.*

Charter. A charter is a legal *document* (paper) that tells the name of the corporation, how it will be *financed* (paid for), and where and how it will do business. First, the charter is *drawn up* (written) by the men who are forming the corporation. Often an *attorney* (lawyer) helps them. Next, this charter is sent to some state official for *approval* (permission to set up a business). After the charter has been approved, the corporation is ready to elect *officers* (the men who will make decisions for the corporation), to sell shares of stock, and to start doing business.

Entity. After a charter has been approved, the corporation becomes an *entity* ("artificial" person). This means that it exists, separate and apart from the men who set it up. As an entity, it has legal rights and duties that are *distinct* (separate) from those of anyone in the corporation. For instance, the corporation can sue and be sued in court. It can make contracts and borrow money. It can hire men and pay them wages. It can buy machines and tools and pay for them.

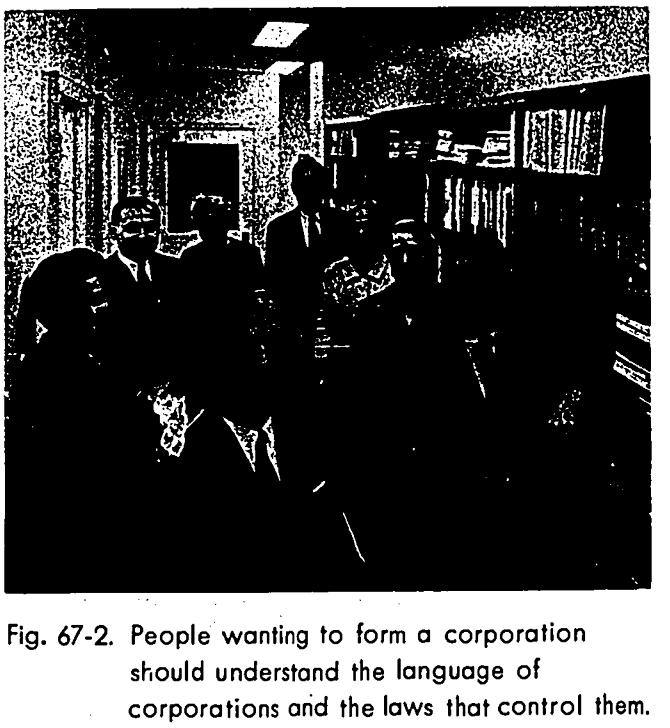


Fig. 67-2. People wanting to form a corporation should understand the language of corporations and the laws that control them. This information can be found in most libraries.

Limited liability. If a corporation can act on its own, as if it were a single person, then who pays the wages of the workers? Who pays the bills for the machines and tools? According to most state laws, the corporation itself must be *liable* (responsible) for its own *debts* (bills). A corporation's officers and stockholders are not liable for things done in the name of the corporation. For instance, if the corporation borrows money that it cannot repay, its stockholders cannot be forced to repay the loan. Thus you can see that the liability is *limited* (restricted) to the corporation itself, not to any of the men who set up or run it.

Longevity. This word means "long life." Since a corporation exists as an "artificial" person apart from any of the men who set it up or run it, it continues to exist even if they die or leave the company. Thus the corporation we are thinking of forming to make and sell desk lamps can "live" as long as it can make and sell enough lamps to pay its bills and make us a profit.

The Business Corporation Today

About one-fourth of all American business is done by partnerships and proprietorships. The other three-fourths is done by corporations.

This is not the whole story. There are more than a million American business corporations, but over 600 of them are giants. Each one of these giants is worth more than $100 million, and together they do more than half of all the business in the United States.

In manufacturing, corporations are also the most common form of business. They do more than 90 percent of all the manufacturing done in the U.S. About 300 giant manufacturing corporations own about 60 percent of the *assets* (land, buildings, tools, and machines) of the industry.

In our story, when we put our desk lamps on the market, we will be going into the industry that makes and sells lighting equipment. These are very small corporations, compared to the giants. On the average, they employ 142 workers and sell about $3 million worth of lighting goods (including desk lamps) each year. This is our *competition* (other firms that make and sell the same products we do).

Advantages of Corporations

Should we form a corporation to make and sell desk lamps? Perhaps we should, for there are clearly some advantages. For instance, our corporation would be a legal entity. It would have longevity. As organizers, we would have limited liability. It is also easier to get the money to start a corporation than it is for any other form of business. After our charter is approved, we can sell *shares of stock* to get money to buy what we need to start making desk lamps. *Stockholders* (those who buy these shares of stock) might be willing to buy our stock, since they risk only the money they pay for the stock. Because of limited liability, they cannot be forced to pay the *debts* (bills) of our corporation.

Disadvantages of Corporations

Though a corporation would give us these advantages, we should keep in mind several disadvantages. For instance, it often takes more time, effort, and money to form a corporation than it takes for any other form of business. The laws that control our starting a corporation differ from state to state, but forming a proprietorship or a partnership is almost always simpler and costs less money to do.

Another disadvantage is the set of laws that control how our corporation can be run. These too differ from state to state. We may have to hire a lawyer to explain our state's laws to us. He may find out that in our state we have to make reports several times a year on how well our business is doing. This

would take time away from our main job of making and selling lamps.

Corporations often pay higher state and local taxes than any other form of business. Also, the profits of our corporation are taxed twice. First the corporation itself pays taxes when the profit is earned. Then the stockholders pay taxes on this same profit when they get it as income from their stock holdings.

Limited liability is not always an advantage. For instance, very small corporations often have a hard time getting loans because bankers know that they cannot force the corporation's officers or stockholders to repay the loan if the corporation cannot repay it. If bankers won't lend money to the corporation, then its officers may have to promise to pay its debts, just as they would have to do in a partnership or a proprietorship.

Why Form a Corporation?

Now that we have looked at the advantages and disadvantages of corporations, why should we form one? There are several very good reasons why we should.

First, the corporation makes it easier for us to make a large number of desk lamps. The more we can make, the more we can sell. As our sales of lamps increase, we can make more lamps to sell. The corporation can also sell more stocks and bonds. With more *working capital* (money from the sale of stocks and bonds), it can build more plants to make more lamps to sell. Thus a corporation is more *flexible* (can grow easily) than a partnership or a proprietorship.

Next, a corporation can get very good *managers* (people who run its plants and offices). Corporations can often get more good managers than any other form of business.

One final reason is worth keeping in mind. Since a corporation is a legal entity, it must act as if it were a single person. Therefore, no one officer can make decisions that are *binding* (legally forcing) on other officers, Fig. 67-3. In a partnership, one partner can hurt the other quite badly if he makes a poor decision.

Summary

Corporations have grown because more money could be gained from them than from any other form of business. Today there are large numbers of corporations doing business in the United States. A few of them do most of the business.

There are advantages and disadvantages to forming a corporation, rather than a partnership or proprietorship. Some of the advantages are:

1. The corporation exists as an entity that has legal rights and duties distinct from those of anyone in it.
2. No one in the corporation can be forced to pay its debts.
3. The corporation continues to exist long after the men who set it up and run it have died or left it.

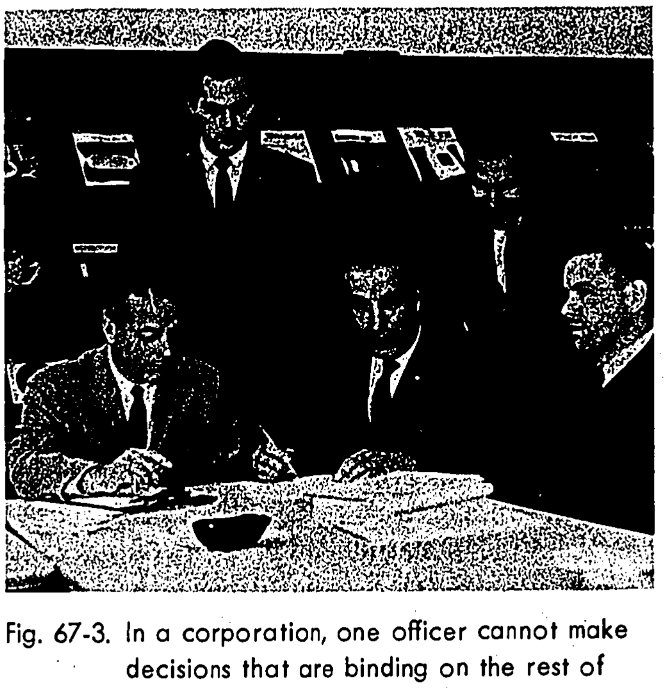


Fig. 67-3. In a corporation, one officer cannot make decisions that are binding on the rest of the officers. In legal matters, the corporation must act as if it were a single person.

4. Corporations make it possible to make large numbers of products, since the money from the larger volume of sales and profits can be used to build more plants to make more products to sell.
5. Corporations can often get better trained people to manage their plants and offices than any other form of business can.

Some of the disadvantages of forming a corporation are:

1. It takes more time, effort, and money to form a corporation than any other form of business.
2. There are more laws controlling the forming and running of a corporation than there are for any other form of business.

Fig. 67-4. A proprietor or a partner must carefully weigh the advantages against the disadvantages if he is thinking of forming a corporation.

3. Corporations pay more and higher taxes than any other form of business.
4. It is often very hard to borrow money for corporations, since the banks know that there is no one in the corporation who can be made to repay the loan.

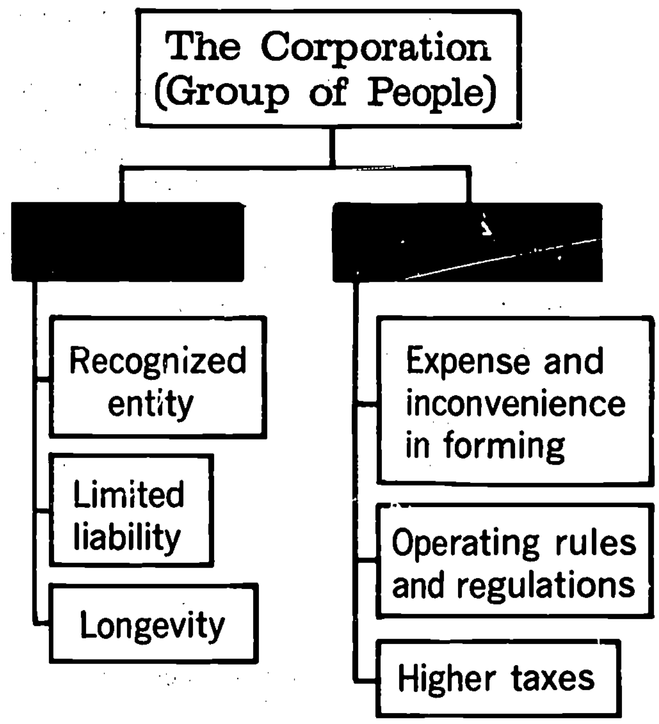
Clearly, anyone wanting to form a corporation in the United States should carefully weigh the advantages and disadvantages of doing so before he makes his decision. This is especially true if he is already in business as a proprietor or as a partner, Fig. 67-4.

Terms to Know

organized
proprietorship
partnership
corporation
joint-stock company
debts
profit
license
guilds
boroughs
exist
artificial person
shares of stock
share
limited-liability law
charter
entity
limited liability
longevity
document
financed
drawn up
attorney
approval
officers
distinct
liable
limited
assets
competition
stockholders
working capital
flexible
managers
binding

Think About It!

1. Look in the Yellow Pages of your local phone book and find five *corporations.* How do you know they are corporations?
2. In this reading, you learned that there are about 300 giant manufacturing corporations. Suppose you have a new service for corporations and you would like to sell it to the largest corporations first. How would you go about finding the names of the five largest corporations?


The Corporation
(Group of People)
[redacted]
[redacted]
Recognized entity
Limited liability
Longevity
Expense and inconvenience in forming
Operating rules and regulations
Higher taxes

Forming a Corporation

READING 68

Men who want to start a new business or a manufacturing company usually start by forming a *corporation.* In the last reading, you learned something about corporations and their advantages and disadvantages. In this reading, you will learn how corporations are formed so that you will be better able to form one of your own to make and sell desk lamps. There are some kinds of information you must get, and some decisions that you must make, before you can get a *charter.* There is the legal "paper work" (*charters and bylaws*) that you must take care of, before you can plan the future production of desk lamps.

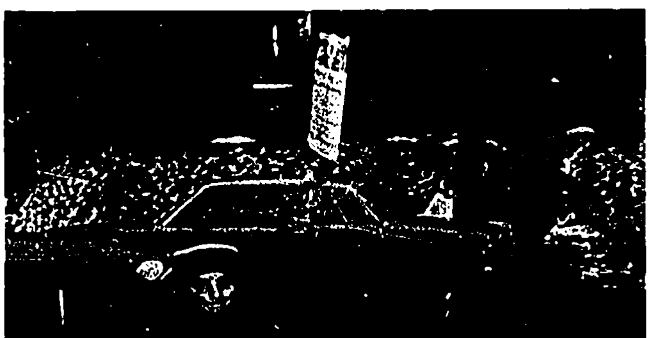


Fig. 68-1. Corporations are started with ideas. Capital, as well as money from one's own savings account, will be needed. Someday this young man may have an idea and use his savings, along with other capital, to start a corporation.

Forming the Public Corporation

You may choose to start your new business as a corporation, rather than as an individual, either alone or with a partner. A corporation is more *permanent* (long-lasting). It will last after the death of its owners. Perhaps the most important advantage of a corporation is that you can sell stocks and bonds to raise money, Fig. 68-1. To start a business, and keep it running until it starts to earn you profits, you need large amounts of money.

If you are forming a corporation to make and sell desk lamps, you must find out how much *working capital* (money to buy *fixed capital* like buildings, tools, machines, etc.) you will need to set up the plant and run it for several months. You will probably have to make and sell lamps for about six months before the income from their sales equals the cost of making them.

After you find out roughly how much money you need, you must decide how you will try to raise the money. There are several ways you can do this. The most common ways are (1) sale of stock, (2) bank loans, (3) loans from individuals (often family and friends), and (4) sale of bonds. *Financial* (money) experts may help you decide which of these ways would be best in your case.

After you have decided how to raise the money you need, you should hire an *attor-*

ney (lawyer), Fig. 68-2. He will help you get a *charter* (legal permission to set up a new business) in a state that is friendly to corporations.

Choosing a State in Which to Incorporate

Choosing where to *incorporate* (set up a corporation) will not be a problem if you are planning to make and sell lamps within the borders of only one state, Fig. 68-3. In that case, you will do whatever that state's laws say you must do. But if your corporation will be doing business in several states, you and your attorney will have to talk over and find answers to many of these questions:

1. How long is the corporation to be chartered? Is it to go on "forever"? Is it to be set up for a definite length of time? In some states, the law says that you must decide this before you can go into business there.
2. Will your corporation own any of its own stock, or must all its stock be sold to the public?
3. What voting rights will your stockholders have? What kinds of voting will be legal? For instance, sometimes stock is sold in two types. Stockholders of one type elect more *directors* than do stockholders of the other type. (Directors are the ones who make important decisions about what the corporation does.)
4. How will *dividends* (profits earned by the stockholders) be paid to the stockholders? Most states have rules that tell you how this must be done.
5. Is there an incorporation fee charged by each state that you want to do business in? If so, how much is it? You should also find out what the taxes are in each state.
6. Where must the corporation hold its meetings? Most state laws say that these must be held in the same state as the home office of the corporation.
7. Do you and your directors have to be

Fig. 68-2. The incorporators must work out the details of the charter before they apply to the state for permission to do business there. Usually, an attorney will be needed to give them legal help.

Fig. 68-3. Choosing the state in which to set up a new corporation is very important. This decision can make the process of incorporation easy. How well the corporation runs also depends on choosing the best state in which to set up the new business.

citizens in each of the states you want to do business in?

8. What do the laws of each state say about *amendments* (changes) to the corporation's charter?
9. Do the laws of any state *limit* (restrict) what your directors can do? Do they limit corporations in any other ways?
10. What is the feeling toward corporations in each of the states? Do they want corporations to do business in their states?

The Corporation Charter

Suppose that you have chosen a state in which to set up your corporation to make and sell desk lamps. You must now *apply* (ask) for a charter from the right state official. Usually this official is the Secretary of State. The charter will show that the state has given the corporation the right to do business within its borders. The following information usually goes into the charter:

1. *Purposes of the Corporation.* The purposes for setting up the corporation must be clearly stated. *Investors* (people who put money into stocks and bonds) will want to know this before they buy stocks or bonds. Banks will also want to know this before they lend money to the corporation.
2. *The Home Office.* This does not have to be the place where most of the business is done, but it must be a place where legal papers and mail can be sent.
3. *Amounts and Types of Stock.* The charter must state the number of shares of stock to be sold and their *par* (basic) *value*. It must also state how much money the corporation has on hand to start doing the business. Normally, not all of the stock must be sold at the time the corporation is set up. The only amount that must be sold at this time is whatever is needed to meet the laws of the state, or needed to raise the working capital to start making the product to be sold.
4. *The Corporation Name.* The name of the corporation should be chosen with care. It should be easy to remember so that the public can pick out your product from others like it. This name can be a real help in selling more stock later on, and in borrowing money when the corporation needs it.
5. *Original Incorporators.* In most states, the names and home addresses of all the people who are setting up the corporation must be listed in the charter. The charter should also tell how many shares of stock each has bought.

The charter should also state how long the corporation will last. Usually this will be the longest time allowed by the state. Some states will grant a *perpetual charter* (one that lasts forever).

After the Charter: The Bylaws

You and the other *incorporators* (those who are setting up the new business) are now ready to hold your first formal meeting. At this meeting, you must do several things. You must elect directors, choose the form of the stock certificate, and sell the stock to all the incorporators. The most important thing you must do is to *adopt* (choose) the *bylaws* of the corporation, Fig. 68-4.

The bylaws state the *regulations* (rules) of the corporation. They state how the business will be run. They must *conform* (agree) to the charter and to state laws. Usually there are bylaws for the following:

1. The duties of corporation officers,
2. The jobs of corporation committees,
3. The rules for selling more stock,

4. The time and place for the meetings of the stockholders,
5. The time and place for the meetings of the directors,
6. The training and experience needed by the directors, and
7. The rules for paying dividends to the stockholders.

Summary

Once you and a group of other people decide to start a corporation, you must carry out the steps needed to get a charter before your new company can do business. You must decide what the purposes of the corporation are. You must pick a location for its home office. You must choose a name for your new corporation. You must decide what types of stock your corporation will sell. After the charter is approved by the right state official, you must all meet to work out the bylaws and the many details of how your new business will be run. In the next reading, you will learn how people fit into a corporation.

Terms to Know

corporation
charter
bylaws
permanent
working capital
fixed capital
financial
attorney
incorporate
directors
dividends
amendments
limit
apply
investors
home office
par value
perpetual charter
incorporators
adopt
regulations
conform
legal residence

Think About It!

1. Where in your town or city would you go to find the *rules* and *regulations* that control *corporations* in your state?
2. List three major manufacturing corporations that have their *legal residence* in your state. How did you find this out?

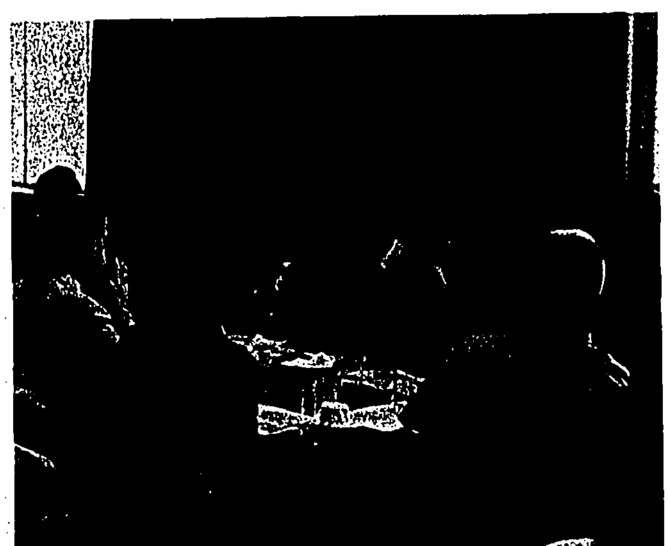
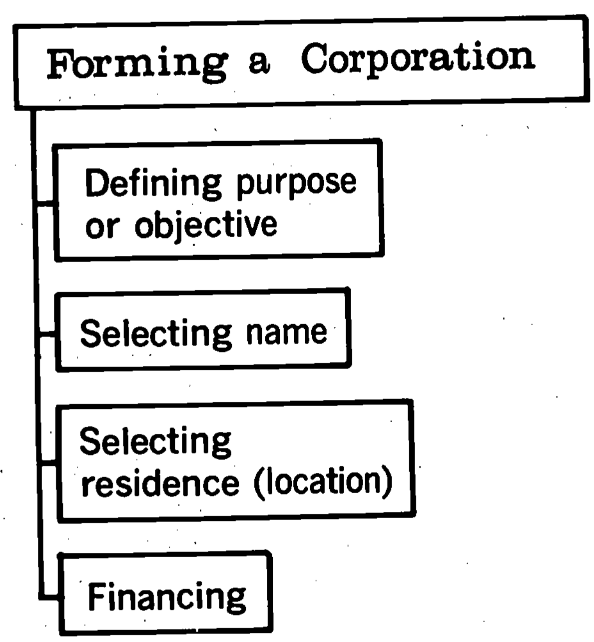


Fig. 68-4. After the charter has been approved, the incorporators must meet and adopt the bylaws of their corporation.



Relating People to the Corporation

READING 69

In your readings last semester, you learned about manufacturing personnel technology. There are five main steps in personnel technology. They are (1) *hiring*, (2) *training*, (3) *working*, (4) *advancing*, and (5) *retiring*. In this reading, you will learn about the ways that corporations carry out these steps. You will also learn about personnel relationships within the corporation.

Management Personnel

Managers (those people who run the corporation for the directors and stockholders) do not *directly* add value to the product their company makes. They *indirectly* add value by the *planning*, *organizing*, and *controlling* jobs they do.

What kinds of people become managers? See Fig. 69-1. First, a manager must be a *leader* (someone who can make decisions). He must also be willing to learn new things, because new materials, machines, or processes are always being developed. These new developments often mean that changes must be made in the ways things used to be done.

A manager must be willing to *support* (back up) company rules. He must also be able to explain them to the people who work for him. He must be able to get along well with other people, for he must work with other managers, his *superiors* (bosses), and production workers.

A manager must also be a person who wants to get a job done. He is not interested in whether he will be able to leave the office on time every day, nor in whether he is doing more than someone else. He must be strong and healthy, for his job is very tiring.

A manager must be able to do things well. After he completes high school, he should get more training in management skills that he will need to do his job well. For some management jobs, he will need a college degree with special training in marketing, production, finance, accounting, or management. For other management jobs, he will need junior college work in data processing, accounting, or sales.

For still other management jobs, he will need technical knowledge. For these jobs, a manager should have gone to a technical

Fig. 69-1. There are many jobs for people to do in corporation management. The person who often becomes a manager is eager, can get along well with others, and can carry out high-level management jobs.

training school. Some managers may get the knowledge they need for their jobs through technical or business courses from correspondence schools. Still another group of managers, such as engineers and research or testing managers, will need special college work in engineering, statistics, chemistry, physics, or other highly technical fields.

Besides the knowledge he needs for any management job, there may be some special training and skills that a manager can only get through work experience. Some managers must have worked on a production job in order to get some of the knowledge they need, Fig. 69-2.

Each year, as technology grows, so does the need for special kinds of managers. In a modern corporation, this means that managers are usually hired who have had the basic training and experience for their jobs. But they must often be trained further in some special skill they need for the management job they are going to do. This may be done through on-the-job training in the company or at a special school. This is an important part of the relationship between a corporation and its managers. When a corporation trains its own managers, it often builds up loyalty towards the company. At the same time, it builds up a strong feeling in the managers that they can do a good job for the company.

Planning and Organizing Functions

The manager has an important job. He helps to plan the goals, the purposes, and the rules of the corporation. He may plan *market research* to find out what product customers will buy. He may guide the work of designing a good product, making the product in the best way, and keeping up the good quality of the product.

It is the manager who *organizes* (sets up) the corporation to get things done, Fig. 69-3. He decides what and how many departments the corporation will have. For instance, he may decide whether sales and marketing will be one department or two. He may also decide whether production in all plants will be run from one central production office, or whether each plant will have its own production manager who will be in charge of the production only in his own plant.

Fig. 69-2. Sometimes a person who wants to become a manager must have production experience. He needs this in order to do part of his management job well.

Fig. 69-3. Managers must make decisions. If they cannot make decisions about how the corporation must run, work will not get done.

Controlling Functions

Once the corporation is set up and is making products, managers are needed to help control what the corporation does. The highest level of control is to direct the whole work of the corporation. The manager in charge of this job is the president. To help him, he often has several vice-presidents, each in charge of a certain kind of work. There may be a vice-president in charge of production, one in charge of finance, and one in charge of sales. Under each of these managers, there will be managers who are in charge of more specific jobs. There is a manager who is in charge of *monitoring* (checking) production. There are managers who are in charge of *correcting* poor work in production, quality control, or inventory.

Production Personnel

In manufacturing, production workers *directly* add value to raw materials by changing their form. There are skilled, semiskilled, and unskilled workers. Without them, nothing would be produced.

To make a desk lamp, many different skills are needed for the many different production jobs. Work like unloading raw materials from trucks is unskilled. It takes very little skill or schooling to do this job well. Work like running a stamping machine or drill press is semiskilled. It takes more skill to do this well. Work like welding is skilled. It takes even more skill to do this well.

In any production line, it is important for each worker to do his job well. Each job on a production line depends on each of the others being done well. If one worker does a poor job, no one else can do as well as he should.

Like the manager, the worker should be willing to support the company and its rules. This does not mean that he may never disagree. When he has a complaint, there is usually a way for him to tell someone who can do something about it, Fig. 69-4.

Like the manager, the worker should try to get along well with others. It is easier for everyone to do a good job when people who work with each other are friendly.

The worker can often upgrade his skills or his knowledge. If he does, there are usually ways for him to be *promoted* (moved upwards) to a new job where he can use his new skills or knowledge.

How much schooling a production worker needs to do his job depends on his work. Good managers will put a worker on a job most nearly suited to his skill and schooling. Unskilled workers may not have finished high school. Semiskilled workers usually have finished high school, and may even have gone to school a year or two after high school. Skilled workers usually have gone to a trade school, or have trained as an apprentice. They have often gone to a junior college. Most companies train their

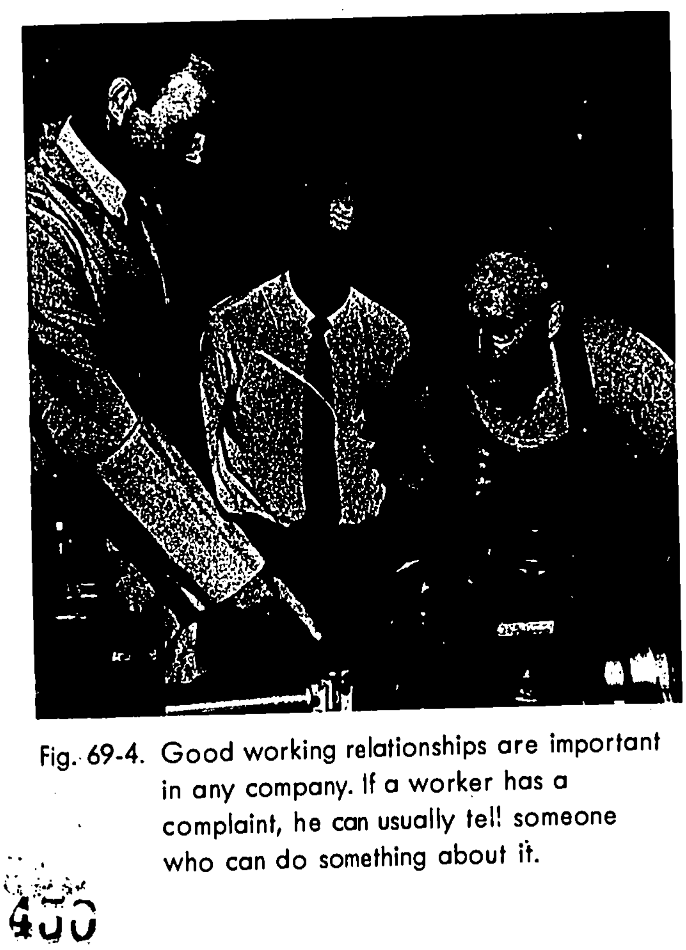


Fig. 69-4. Good working relationships are important in any company. If a worker has a complaint, he can usually tell someone who can do something about it.

own workers for certain jobs, Fig. 69-5. There are on-the-job training programs which help the worker learn any special skills he needs for the job he was hired to do. Also, many companies like their workers to take correspondence courses in order to learn new skills.

There are many different production worker jobs in any manufacturing plant. *The Dictionary of Occupational Titles*, published by the U. S. government, lists hundreds of production jobs and the skills and schooling a worker needs to get them. Jobs that have many common duties are grouped in the same class. For instance, all electrical workers work with electricity. Some of them may make electrical parts, others may assemble electrical products, and still others may test and repair electrical products. For each of these jobs, the worker needs a different kind of schooling, training, and skill. Yet all will be listed under the general heading, "electrical worker."

Personnel Practices

The corporation can make sure that it is known as a fair employer through its *personnel practices* (how it treats its workers). An *applicant* (someone who wants a job) for a job should be chosen, or rejected, for reasons that are fair, and that he can understand. When someone is hired, he should know just what his job will be. Training for any job should be well-planned. The corporation should pay a fair wage, and should make sure that there is a good physical setting (Fig. 69-6) and a friendly place to work in.

Workers should know what they must do in order to be advanced and promoted. They should also know for what reasons they may be *demoted* (moved downward). There should also be written rules for firing a worker, so that if this happens, the worker knows why it was done. These are all things a corporation can do to make workers feel good about working there.

When a corporation treats its workers well, they usually do their jobs well. When workers do their jobs well, the customers

Fig. 69-5. The corporation may hire full-time teachers to give on-the-job training to their workers.

Fig. 69-6. The corporation must understand what its workers need to do their jobs well. This man is studying the sound level near a machine. If the noise level is too high, then the noise will be reduced so that the workers can do their jobs well.

who buy desk lamps get a good product at a fair price. You can see that everyone gains when a corporation and its workers treat each other well.

Through labor-management talks over wages and benefits, good corporation management understands what its workers need to do their jobs well. When sales begin to fall off, it finds out why customers are not happy with the product. The corporation which does not pay any attention to its workers or its customers soon goes out of business.

Relationships with Other People

Besides managers and production workers, the corporation needs to treat other people well. In our desk lamp company, its salesmen sell lamps to *retail stores* (those who sell the lamps to the public). The salesmen in these retail stores must like the product if they are going to sell many desk lamps to the public. The customer must like the product if he is going to buy more desk lamps, or tell his friends to buy them. Usually, if a product is liked, the company that makes it is also well-liked. If the product is not liked, then the company that makes it is not liked.

Salesmen and customers are not the only people that must like the product and the company that makes it. Advertising people must like the product (and the company), since their work helps to sell the desk lamps in the first place. Service workers must also like the product (and the company), since they are the ones who keep it working well after it has been sold to the customer.

There are many other people who work for the corporation in *supportive jobs* (those that do not make the product but are needed to get it ready for the customer). Many companies now hire doctors and nurses to take care of sick and injured workers right there in the plant, Fig. 69-7. Other supportive workers can be found in the accounting, purchasing, and sales departments. Most of them do *clerical* (record-keeping) work, Fig. 69-8. These people are not managers, because they do not direct the work of other people or make many important decisions. They are not production

Fig. 69-7. People may work in such supportive jobs as medical care for corporation workers.

Fig. 69-8. All corporations need clerical workers to handle office work in accounting, purchasing, and sales departments.

workers, because their work does not change the form of the raw materials in any direct way. Many of these workers get their training on the job, though sometimes not in jobs in a manufacturing corporation. Most of them have had training in clerical skills, either in high school or in business school

The corporation must treat these workers as well as it treats managers and production workers. When they are treated well, clerical workers often stay with a company for many years. Usually, the longer they stay, the better they do their jobs.

Terms to Know

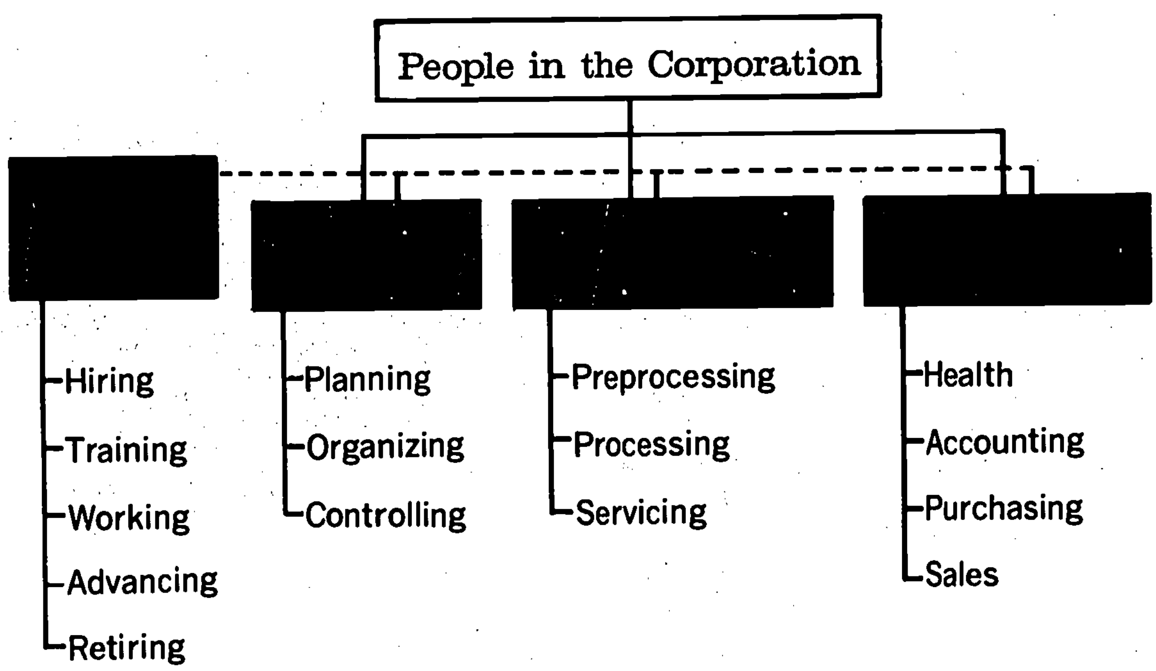
hiring
training
working
advancing
retiring
managers
directly
indirectly
planning
organizing
controlling
leader
support
superiors
market research
organizes
monitoring
correcting
promoted
The Dictionary of Occupational Titles
personnel practices
applicant
demoted
retail stores
supportive jobs
clerical

Summary

Corporations try to hire workers who can do the jobs needed to make and support their products. They also try to hire people who can get along well with each other. Corporations must understand the feelings of both their workers and their customers. If these feelings are ignored, the corporations may have problems with their workers and may have trouble selling their products.

Think About It!

1. Many people have the wrong belief that managers are "better" than production workers. In today's complicated world, there are advantages and disadvantages to both jobs. List three advantages of being a production worker. Also list three advantages of being a manager.
2. Look at the want ads in a recent issue of your local newspaper. Were there more job openings for managers or for production workers? Why do you suppose this is true?



Making the Sales Forecast

READING 70

Earlier in these readings, you learned that *surveys* (studies) are made to find out what products *consumers* (buyers) want to buy and what prices they want to pay. In this reading, you will learn how management uses such surveys, along with other *economic data* (information about money matters), when a company is planning to make a new product.

The Market Survey

You remember that you have formed a corporation to make and sell desk lamps. You have not yet decided what type of desk lamp your firm will make.

If your firm were already making other products, it would have a plant, tools, machines, and trained workers. You and your managers would want to use these to make your new product. You would ask yourselves this question: What kind of lamp can be made on our machines, in our plant, by our workers?

However, since you are just setting up your corporation, it does not yet have a plant, machines, or workers. Before you can begin making desk lamps, large amounts of money will have to be spent for these *inputs* (what is needed to start production). Therefore you and your managers will need to know just how many of what kind of desk lamps you can sell. In what price ranges do the lamps sell that are made by your *competitors* (those also in the business of making and selling desk lamps)? What styles of desk lamps do they make? The decisions you make about style and price will depend partly on how strong your *competition* is.

You must also know what the buyers of desk lamps want and need. What does the person who buys a desk lamp want it to do? What should the lamp look like? How much should it cost? What service does the customer expect from the firm that makes the lamp he buys? The kind of lamp you make depends on the answers to these questions.

When your corporation has decided what kind of desk lamp it will make, you must next decide what price you will sell it for. *Market research teams* (people who find out what people are buying and how much they are paying for what they buy) can get *data* (information) for you about the prices of the lamps made by your competitors, Fig. 70-1. One way they do this is to average the

Fig. 70-1. A market researcher gets data about prices of competitors' products to help set a price for the corporation's own products.

prices of the other lamps. This average will show you how much the buyer is willing to pay for a desk lamp.

A more precise way to set your price is to find out what prices desk lamps sell for, and how many lamps are sold at each price. But this kind of data is usually hard to get. Your competitors won't usually tell you exactly how many lamps they have sold. You know that the price on your lamps should not be too much higher nor too much lower than the lamps being sold by other firms.

Economic Data

A *market analysis* is a study of what people are buying or what they have been buying recently, Fig. 70-2. It should also include data about the economic future. If sales are rising, this might show that customers would be willing to buy desk lamps. If sales are falling, this might show that customers would not be buying very many desk lamps. *Economic data* (information about money matters) published by the government and the lamp industry itself can be very helpful here. Such data are gotten from the business census which the government makes each year. This yearly census is one of the most trusted sources of data about what business will be like in the next year.

To make a *sales forecast* means to predict what the future sales of some product will be. Sales forecasting is done by many people using a lot of special data. The data used to make these forecasts are usually gotten by a market research team. This team collects the data and *evaluates* (judges) it for its *accuracy* (correctness), Fig. 70-3. These data may include the total number of desk lamps sold, say, during the month of June, and the kind of customers who bought them. For instance, they may have been bought by schools, offices, or individuals. After the data have been judged, they are reported to specialists in marketing and sales. It is their job to use these data to predict the sales of new desk lamps in, say, the next six months.

Once they have completed their forecast, they must report it and explain it to you and your management. You will then decide

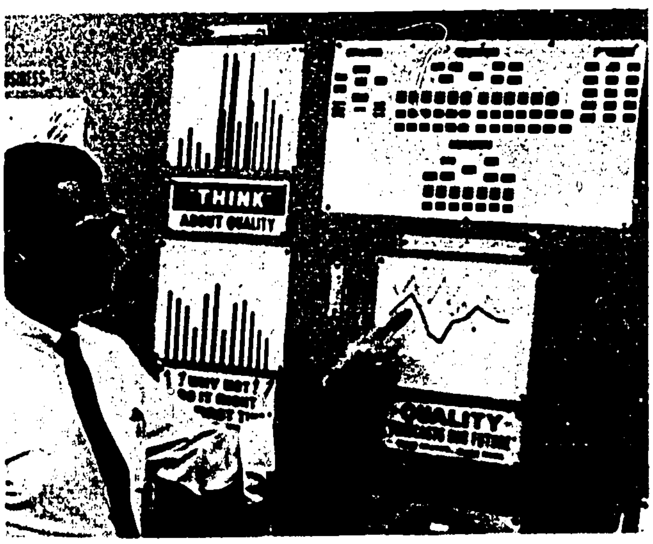


Fig. 70-2. The data about what people are buying, or have been buying, may be shown on a graph. This graph can help the researcher predict the economic future of a company's products.

Fig. 70-3. The data from market research are put on cards and the cards are sorted by this machine. The data are used to make the best decisions about next year's business.

what kind of lamps and how many will be made in the next six months. Perhaps the data show that a low-priced, modern lamp will sell as well as a high-priced, traditionally-styled lamp. You and your managers will have to decide if your corporation will make one of these lamps, or both of them. The profits you will make depend on the correctness of the forecast and the decisions that you and your management make based on that forecast. Thus the data for your decision-making must be as correct and complete as possible, Fig. 70-4.

Using the Data

The decisions you make based on the sales forecast data will help you set the goals and standards of your corporation. If you decide to make a high-priced, high-quality lamp, your firm will have to plan for high standards in raw materials, production processes, and production quality. All rules set by your corporation will be aimed at producing this kind of lamp.

Fig. 70-4. Computers can also help management find out the amount of inputs needed to start production of new products.

The data may also be used to tell you what kind of departments your corporation will need. For a high-quality lamp, you will need more careful testing than you would for a low-quality lamp. Thus your testing department would have to be more *elaborate* (complex and detailed) and more costly.

The same data will also help you and your managers plan the design of the desk lamp, the engineering that will be needed, and the production details for the lamp, Fig. 70-5.

A final use of the data is to get *working capital* (money for land, plants, machines, and tools). If a corporation is known for making a profit, then banks will be willing to lend it money to buy more machines and tools. Often if a corporation can show a sales forecast for a new product, it can easily sell more shares of stock. These are ways to keep a good business going. If your corporation is a new one, it must depend a great deal on sales forecast data to get the money needed to get started making desk lamps.

Summary

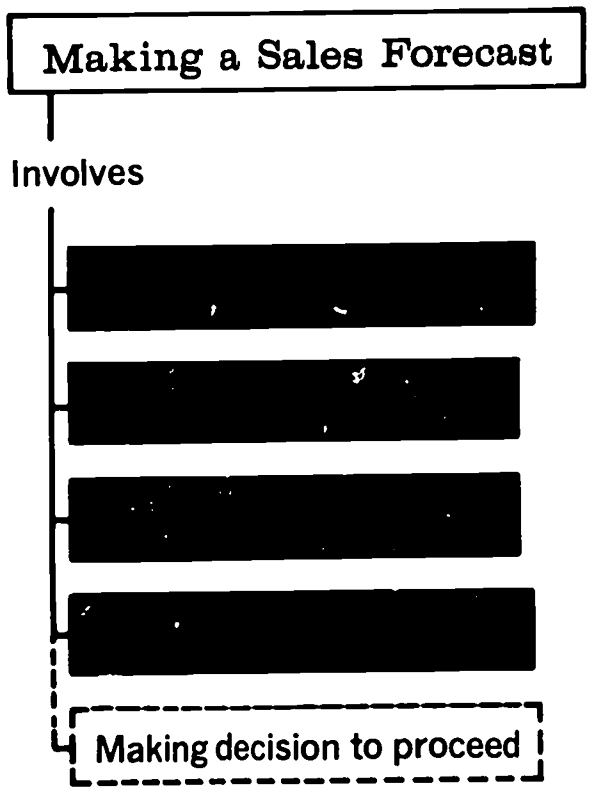
There is one major question you and your managers must answer: What kind of desk

Fig. 70-5. The reactions of consumers to material for lamp shades will be studied by management in order to decide what materials to use.

lamp will customers buy, in what quantity, at what price? Market research must find out for you what color, style, and performance the buyer would like in a desk lamp. You and your management must compare these data with the cost of making such a desk lamp. You also need price and sales data on the lamps sold by your competitors. You also need sales forecasts that show what kind of business you might do in the future. Whatever decisions you and your managers make about the kind and quality of desk lamp to make, you will not be able to start making desk lamps to sell until you can study all these data. Then you must make the best decisions you can, even if you must compromise between the best design for a desk lamp and the cost of making it.

Think About It!

1. Look at a breakfast cereal box. What kinds of data must the cereal manufacturer get before he manufactures and markets the cereal at the price shown on the box?
2. New products are always being put on the market. Name a product now on the market that was not heard of five years ago and suggest why this product was developed.



Terms to Know

surveys
consumers
economic data
inputs
competitors
competition
market research teams
data
market analysis
sales forecast
evaluates
accuracy
elaborate
working capital

Obtaining Capital, Estimating Profits and Keeping Records

READING 71

Capitalism is an economic system in which corporations (and other kinds of business organizations) can form and operate in order to earn a *profit* (what is left from income after the bills have been paid). *Capitalization* refers to the whole process of getting the money a business needs to get started.

Many records must be kept by a corporation. Some records deal with *economic* (money) matters. Others deal with the day-to-day work of the corporation.

In this reading, you will learn about capitalization, earning profits, and keeping corporation records.

Definition of Capitalization

In order for any corporation to get started making products to sell, it must have money. Capitalization is the process of finding out just how much money is needed, deciding where to get it, and then raising it.

Sources of Capital

Individuals and businesses can *invest* (put money) in corporations in four ways. These ways are (1) *stock*, (2) *bonds*, (3) *bank loans*, and (4) *short-term credit*. In each case, those who put money into corporations hope that their *investment* (money put into the corporation) will bring them a profit.

Stock is the form in which ownership of a corporation is sold. The ownership is split into a large number of equal parts, called *shares*. These shares are then sold to raise money. The *investors* (those who put money into corporations) are really buying part-ownership of the corporation when they buy *shares of stock*. These investors are called *stockholders*, or *shareholders*.

When a corporation makes a profit, this profit belongs to its stockholders (shareholders). The board of directors of the corporation may decide to divide it among the stockholders. Profits earned by the stockholders are called *dividends*.

Bank loans are another source of *working capital* (money needed to buy land, buildings, tools, and machines). When money is borrowed from a bank, the borrower must sign a *note* (loan agreement). He *pledges* (promises) something worth money as *security* (something that can replace the loan if it is not paid back). A bank loan has to be paid back with *interest* (money paid to borrow money), Fig. 71-1. If a corporation

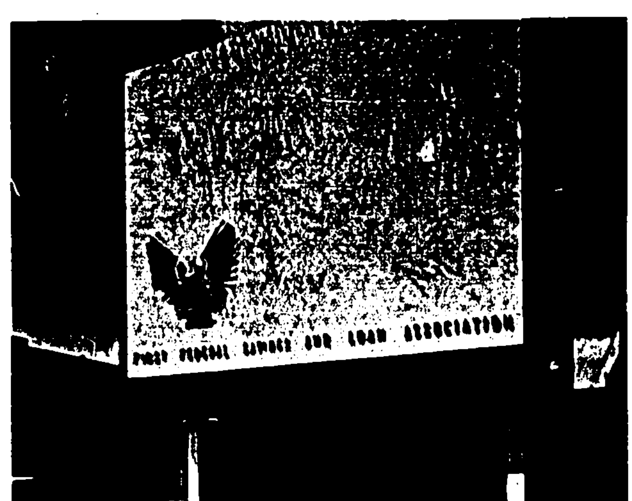


Fig. 71-1. Banks and other loan companies lend money to get new corporations started. This borrowed money must be paid back with interest.

cannot pay back the loan, the bank can take over the corporation's buildings or machines, or whatever was pledged as security for the loan.

Bonds are not like stock. The investor who buys a bond does *not* own any part of the corporation. Bonds are more like bank loans. The corporation that sells the bonds must pay back the bondholder's money with interest.

A corporation can buy certain things like office supplies, raw materials, tools, and some machines on *short-term credit*. This means that the corporation has several months to pay for them. The corporation can, of course, use these things before it has to pay for them.

Determining Capital Needs

In earlier readings, you learned how to set up your corporation to make and sell desk lamps. Now you will learn how to raise the money to get it started.

First you should find out how much money you will need to start making lamps. Then you subtract the amount you and the rest of the *incorporators* (people setting up the corporation) will put into the company, Fig. 71-2. The difference is the amount of money you will have to raise so that your corporation will be ready to start making desk lamps.

Suppose that you need $67,000 for full capitalization of your corporation. This $67,000 will be used to pay for the following:

Building	$22,000
Plant Equipment	15,000
Office Equipment	5,000
Tools	4,000
Furniture	1,000
Operating Funds	20,000
Total	$67,000

Suppose that you and the rest of the incorporators will put in a total of $7,000 from your own savings. This means that there is still $60,000 that must be raised. You can raise this money either by borrowing it or by selling shares in your corporation.

Suppose that you and the rest of the incorporators decide to borrow $20,000 of this $60,000, and to raise the rest of the $40,000 by selling 400 shares of stock at $100 per share. Of course, an additional 70 shares of stock will be sold to you and the rest of the incorporators in return for the $7,000 you all have put into the corporation to get it started.

Estimating Cost and Selling Price

You should find out now whether your corporation can make a profit if it makes and sells desk lamps. Can it make enough lamps, and sell them at a high enough price, to pay its *operating expenses* (light, phone, and fuel bills; wages and salaries; etc.)? Can it make enough to pay the *interest* on

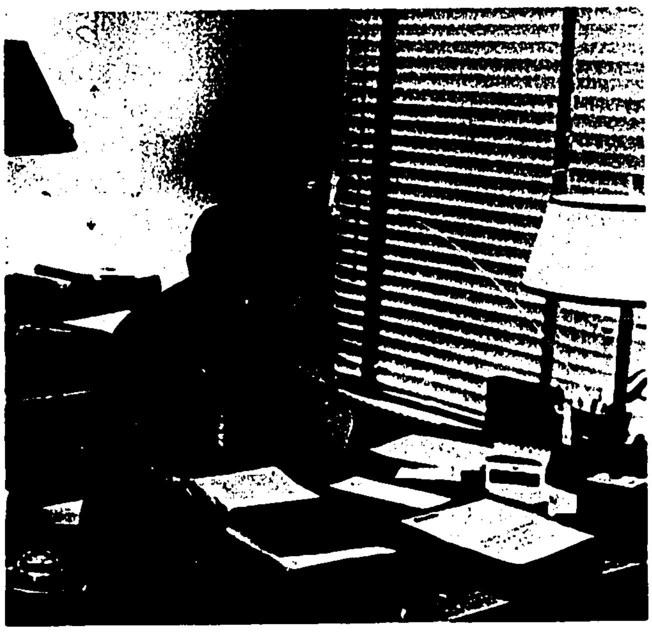


Fig. 71-2. Each incorporator must check carefully to see how much he can invest in the new corporation. This money will become part of the capital the new corporation starts with.

the $20,000 you intend to borrow? Can it make enough to pay *dividends* to the stockholders who own $47,000 worth of stock sold to raise capital?

Suppose a sales forecast for your corporation showed that there would be buyers for at least 5,500 lamps (and maybe as many as 11,000) at a price of $8 each. You must next find out how much it will cost you to make lamps like these.

Suppose you think you can sell 7,000 lamps (somewhere between the lowest and the highest figures in the sales forecast). The cost of making each of these lamps is figured in two steps. First, the labor, materials, and overhead costs for 7,000 lamps are *estimated* (predicted) and added together:

Labor	$17,900
Materials	16,900
Overhead	10,200
Total manufacturing cost	$45,000

This figure is divided by 7,000 to find the *unit cost* (cost of each lamp):

$$\frac{\$45{,}000 \text{ total manufacturing cost}}{7{,}000 \text{ lamps}} = \$6.43 \text{ each}$$

Now you use the figure $6.43 as the cost of making each lamp. You subtract this from the selling price of the sales forecast to find the *markup*. The markup is the amount of profit you will make on each lamp, if all of your estimates of cost are correct.

Selling price	$8.00
Cost price (unit cost)	−6.43
Markup (profit per lamp)	$1.57

Estimating Gross and Net Profit

Now that you know how much profit you can make on each lamp, you can figure out how much you can make on all the lamps, Fig. 71-3. To find this *gross profit*, you multiply the markup ($1.57 per lamp) by the total number of lamps you think you can sell (7,000).

Markup	$1.57
Sales forecast	×7,000
Gross profit	$10,990

Out of this gross profit of $10,990, the corporation has to pay taxes and dividends. Suppose in your state that corporation, state, federal, and local taxes will come to about one-fourth of your gross profit. For the 7,000 lamps, this will be about $2,800 ($\frac{1}{4} \times \$10{,}990 = \$2{,}747.50$).

There are other firms that make and sell lamps. From the profit statements they publish, you may learn that they usually pay dividends to their stockholders of about 9 percent on their investments. To get people to invest in your new corporation, you will need to pay 10 percent (about 1 percent more than companies already in business). Dividends of 10 percent, paid on $47,000 worth of stock, will come to $4,700 (10% × $47,000).

Fig. 71-3. The gross profit will be figured after labor, material, and overhead costs have been figured.

Your corporation would find its *net profit* (what is left after taxes and dividends have been paid) in this way:

Taxes	\$2,800
Dividends	+4,700
Total taxes and dividends	\$7,500
Gross profit	\$10,990
Total taxes and dividends	− 7,500
	\$ 3,490

The \$3,490 that is left is called the *net operating profit.*

Operating Profit

Net operating profits are usually left in the treasury of a new corporation until they are needed. Net profits can be used to pay higher wages, to buy more tools and machines, or to take care of a future loss. Net profits cannot be used to pay any of the incorporators or corporation officers. They already have been paid salaries and as stockholders themselves, they have already gotten dividends from the gross profits. Only stockholders can get any of the net profits, because the corporation's profits legally belong to its stockholders. In your new corporation, if the net profit of \$3,490 were to be paid out to the stockholders, it would have to be divided among *all* of them.

Keeping Records

All companies must keep *records* (accounts) of all *transactions* (sales, loans, purchases, wages paid, etc.) that take place as part of doing business, Fig. 71-4. Corporations spend a lot of time and money just keeping their large numbers of records up-to-date.

Since your new corporation is getting ready to make and sell desk lamps, you will need records of many facts and decisions. Some of these will be called *business records.* There will also be *production records, marketing records,* and *personnel records.*

Business Records

Among your *business records* will be the incorporation records of your company. These are like a birth certificate. They show when, where, and by whom your company was started. They also show how much money it had when it started, what it will produce, how it will be run, and who will direct it. These facts are set out in the charter and in the *minutes* (official record) of the meetings of the directors and the stockholders.

There must also be records of all leases that your corporation has signed, all real estate it owns, and all insurance it has taken out, Fig. 71-5. There must also be a calendar that shows when the *financial year* of your company begins and ends. This may be quite different from the regular calendar year. This calendar shows when the board of directors will meet, when the stockholders will meet, and when all business reports must be made.

Another kind of business record is needed for the bonds your corporation sells. It will show when the bonds were sold, when they are due to be paid off, how much interest

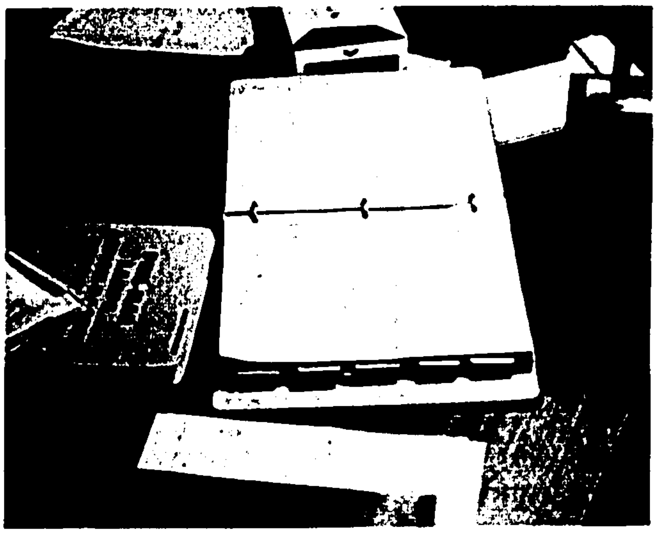


Fig. 71-4. Careful records must be kept on all business transactions. A mistake during capitalization could ruin the new corporation.

must be paid to the bondholders, and when these interest payments must be made.

Stock records for your company must show how much stock your company can sell, how much of it has already been sold, to whom it has been sold, when it can sell new stock, and how much new stock is sold. A record of dividends paid to stockholders must be kept that shows how much, to whom, and when.

There are sales records, income records, and tax records. These are used to make up the two basic financial statements of the company. They are (1) the *profit and loss sheet* (income statement) and (2) the *balance sheet*. They show the financial health of the company, how it has improved or suffered in the last several months, or what its condition was at some single point in time, Fig. 71-6.

Production Records

Production records deal with the details of making desk lamps in your company. Purchase records show what materials have been bought. Inventory records show what materials are on hand, how many partially finished desk lamps are in process, and how many finished desk lamps are in stock. There are also quality control records, inspection records, production-rate records, and records of formulas and processes used in making the lamps. See Fig. 71-7. In ad-

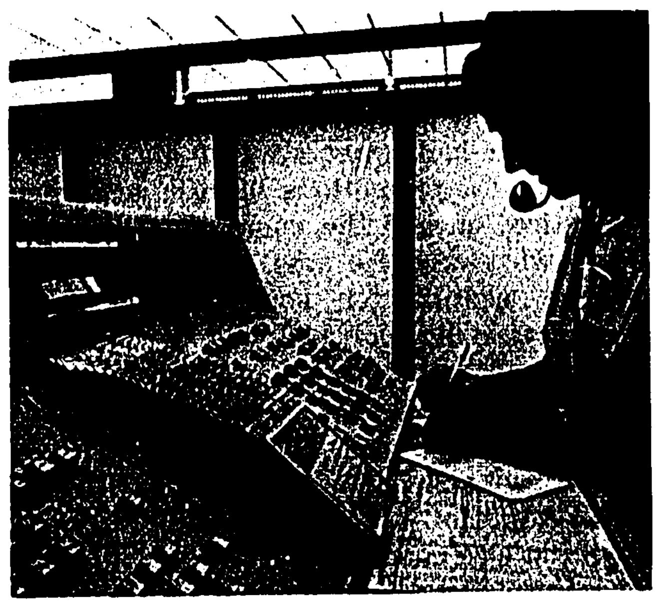


Fig. 71-6. Business records must be kept of all expenses and income. They are needed to make up the financial statements of the corporation.

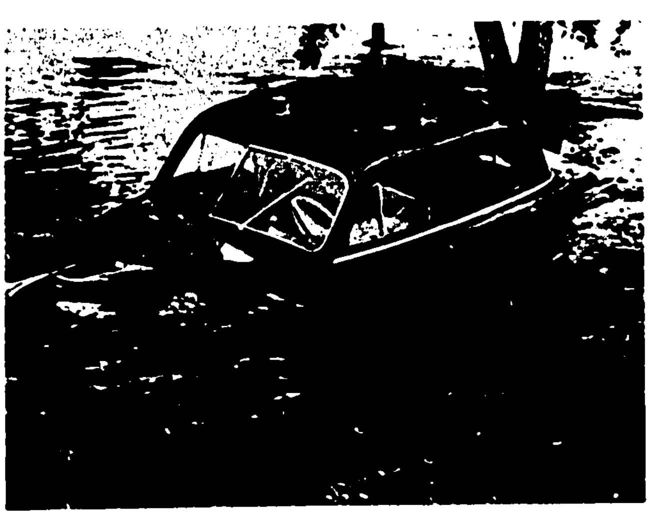


Fig. 71-5. Suppose this flood had happened on corporation property and the car was owned by the corporation. Records of insurance would be needed so that damage claims could be made in the name of the corporation.

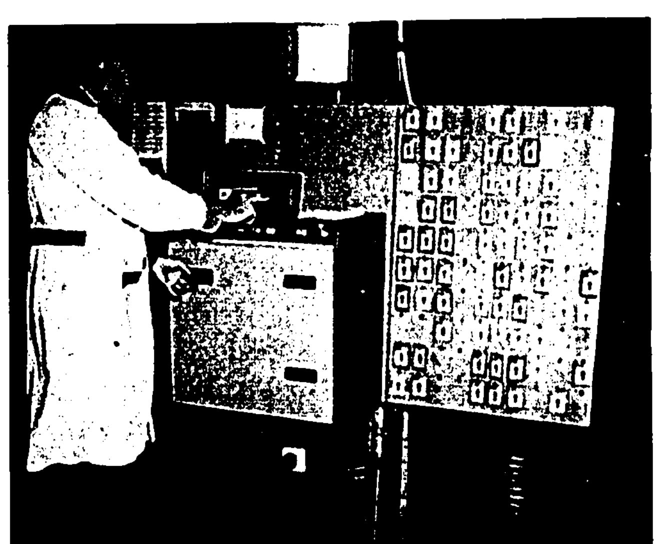


Fig. 71-7. Here, production data are being recorded and retrieved for use. This is just one example of efficient record-keeping.

dition, there are records of *capital expenditures* for production. These include the inventory of tools and machines, their maintenance records, and the purchase or lease records of the land and plant buildings.

Personnel Records

Personnel records deal with the people employed by your company. These records show when a person was hired, how much training he had, what kind of work record he had, what promotions he had, and when he retired or left the company. They also show what wage he was making when he started working for your company, how many raises he had gotten and how much they were, and what wage he is making now. They also show how much tax has been withheld from his paychecks, and how much insurance the company is buying for him. They show the number of sick days or vacation days he has coming to him, the retirement benefits due him, and the reasons he left the company if he no longer works there.

Product Research and Development Records

Manufacturers must spend part of each year's profits looking for ways to improve their products. This means that in your corporation, you will have to spend part of your net profits for this year looking for ways to make a better desk lamp. You might even want to spend some of these profits on research that may turn up a new lighting product for future production.

Market Research Records

Market data records show what customers want in a desk lamp, how it should work, what it should look like, and what the price should be.

Correspondence Records

Your *correspondence records* should include letters, memos, and other "paperwork" that your company does to keep in touch with its workers, its customers, and its suppliers and wholesalers. Incoming correspondence can tell you whether your company is making the best quality desk lamp, whether its purchases and sales are too high or too low, or what the attitudes of your customers are toward your company and its product.

Summary

Capitalization means (1) finding out just how much money a corporation needs to get started, (2) deciding where to get it, and (3) raising it. Money will be needed for land, buildings, tools, and machines, and for operating expenses (wages and salaries; phone, light, and fuel bills; raw and standard stock materials; etc.).

A corporation can raise money by selling shares of stock. These are really shares of ownership in the corporation. It can also borrow money from a bank, if the incorporators pledge security for the loan. It may be able to borrow money from investors by selling bonds. Borrowed money must always be paid back with interest to banks or interest to stockholders.

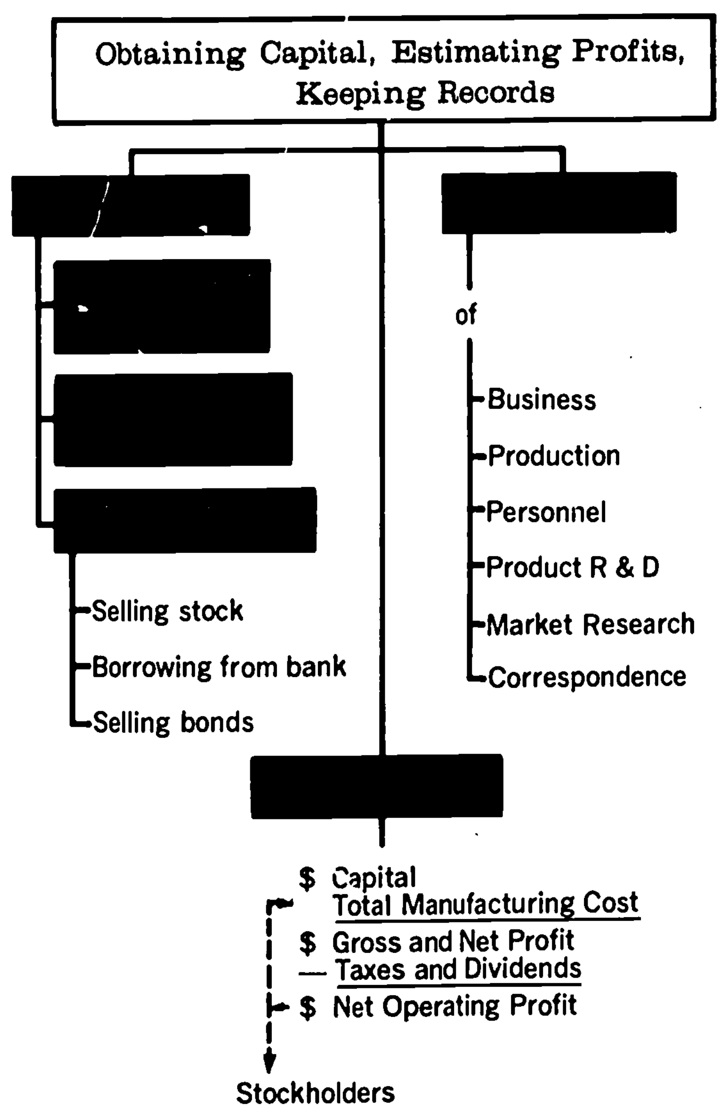
Many different kinds of records must be kept by a corporation. Some of these are kept because of state and federal laws. Others are kept so that the corporation will know where it stands financially. Still others are kept in order to keep track of production, personnel, and product and market research data.

Terms to Know

capitalism
profit
capitalization
economic
invest
stock
bonds
bank loans
short-term credit
investment
shares
incorporators
operating expenses
estimated
unit cost
markup
gross profit
net profit (net operating profit)
records
transactions
business records
investors
shares of stock
stockholders (shareholders)
dividends
capital
note
pledges
security
interest
production records
marketing records
personnel records
minutes
financial year
profit and loss sheet (income statement)
balance sheet
capital expenditures
market data records
correspondence records
financial

Think About It!

1. Your corporation wants to borrow money to manufacture desk lamps. You have been given the job of finding organizations that might want to lend your corporation the money it needs to get started. Where would you look to find the names of lending organizations in your town or city? List some of the ones you find.
2. Look in the *financial* (business) section of your newspaper.
   a. List three corporations that are trying to raise money through the sale of *bonds*.
   b. List three corporations that are trying to raise money through the sale of *stock*.



READING 72

Locating the Plant and Securing Inputs

In earlier readings, you learned that you must get six basic *inputs* in order to manufacture products. These inputs are (1) *natural resources,* (2) *energy,* (3) *capital* (tools, machines, etc.), (4) *finance* (money or working capital), (5) *human resources,* and (6) *knowledge.*

In this reading, you will learn how to choose the inputs that you need to make desk lamps, especially the human and financial inputs. You will also learn how to choose the best location for the plant in which you are going to use all these inputs to make desk lamps, Fig. 72-1.

To Make or Buy Components?

One of the first questions you and your managers must answer is this: Should we make the different *components* (parts) we need to make desk lamps? Or should we buy them already made from other companies? Your answer will be most important. You will need it to figure out the amount of money you need (to buy land, buildings, tools, and machines). You will need it to figure out the size and kind of plant you need. You will also need it to figure out the type and number of workers you need to run the plant. Until you decide whether to make parts or buy them, you won't be able to pick the best place to locate your plant, Fig. 72-2. To decide whether to make or to buy parts, you need answers to the following important questions:

1. Can your corporation make the parts more cheaply than it can buy them already made from someone else?
2. Does someone else already make these parts? If so, can we get them now?
3. Can we always buy these parts, even at much later dates?

Fig. 72-1. A number of possible plant locations can be seen here. The choice of any one of them depends on a number of factors.

Fig. 72-2. Until the plant location is found, the corporation planners cannot start to get all of the inputs needed to manufacture their product.

The first question deals with the *cost of manufacturing*, the second with *availability*, and the third with *continued availability*.

Suppose your corporation has decided to buy some of these parts for desk lamps from other companies, rather than get all the raw and standard stock materials and make all the parts in your own plant. The rest of the parts will be made in your own plant from standard stock materials. All of these parts will then be *assembled* (put together) in the plant. What must you think about when you are looking for the best place to locate your plant? To answer this question, you need a list of all the inputs you will use to make desk lamps to sell.

Inputs to the Product and Plant

The *natural resources input* will be the standard stock materials and the parts (already made) that you buy from other companies (actually, these inputs are no longer *natural* resources). Therefore you will want to be as near as you can to the *vendors* (sellers) of these products. This will cut down *transportation* (moving) costs and speed up delivery of the vendors' products.

You will also need to be near good ways to ship your desk lamps to your customers. Therefore you will need data on *motor freight* (trucking), railway freight (Fig. 72-3), air freight (Fig. 72-4), and water freight services.

You will need to be near a cheap source of power. You will need it to heat, cool, and light your plant, warehouse, and offices. You will also need it to run all the machines in your buildings.

You should also figure out what your *construction* (building) costs will be in any

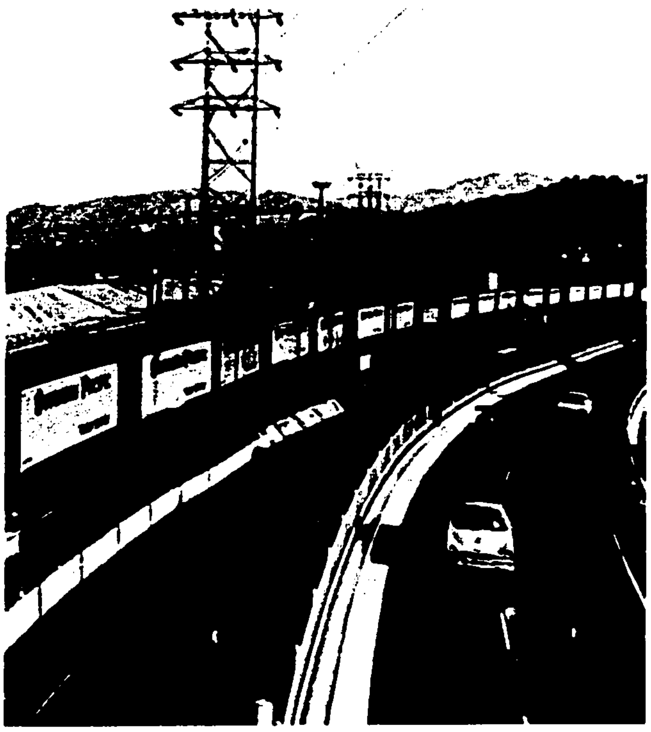


Fig. 72-3. Good ways of moving parts and materials are needed in modern manufacturing. The nearness of highways and railroads may decide the plant location.

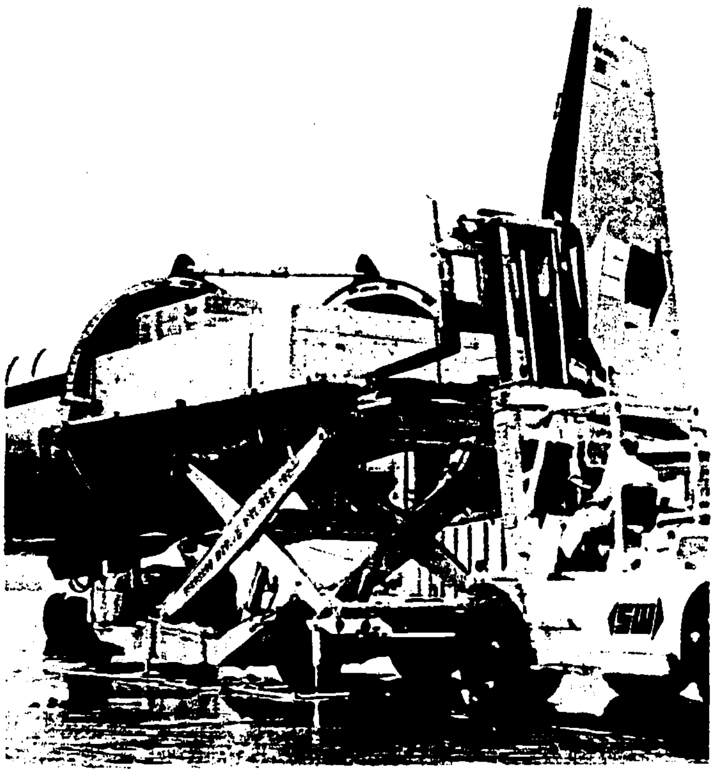


Fig. 72-4. Air freight is another way to move parts and products today. Many corporations use this means for getting their products to their customers.

place you may be thinking about, Fig. 72-5. Building costs differ from one part of the country to another. This will affect your need for working capital.

Often there are local or state laws that control what kind of plant you can build and what kind of product you can make. If such laws exist, how will they affect your corporation? Some of these laws may *prohibit* (forbid) certain kinds of construction and certain kinds of manufacturing.

Can you get tools and machines easily? Will they have to be shipped all the way across the country?

These questions need answers if your plant is to be located so that the desk lamps can be made at the lowest cost and earn the highest profits.

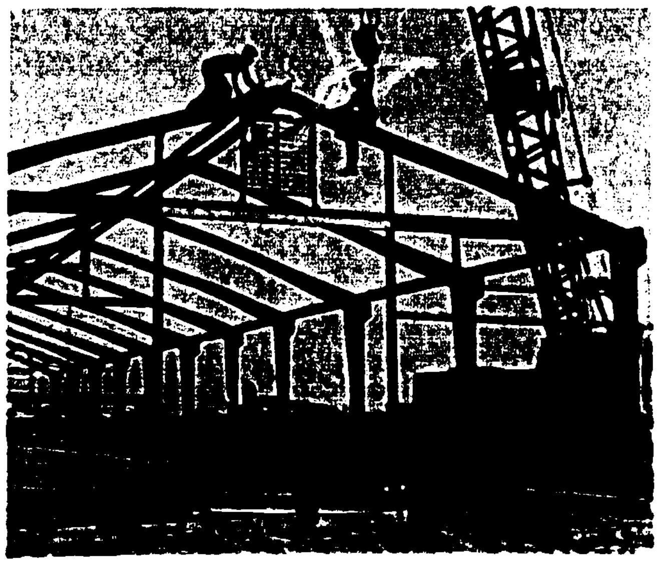


Fig. 72-5. The kind of plant you need depends on what type and how much manufacturing you do. Of course, the corporation must make sure that all of the plant buildings meet the building and safety codes of the town or city they are located in.

Additional Factors Concerning Plant Location

The plant should be located near the markets where the desk lamps will be sold. This way you can keep your shipping cost very low. The tax structure there is very important. High taxes mean high costs. You should look for *tax exemptions* (freedom from paying taxes) and the use of free land that are sometimes given to new businesses in some places. Some towns and cities make such offers just to get more new businesses. These in turn will give more jobs to the local people.

You should find out what attitude the people in these towns and cities have toward manufacturing. Will there be enough people to hire? Will they want to work in your corporation? Will the local and state governments be helpful? Is the town or city friendly? Do the people there want new manufacturing companies, or do they try to keep them out?

What are living conditions like in these towns and cities? Are there enough good houses, schools, churches, shopping centers, and recreation areas? Is there good weather for pleasant living for the workers and their families? If the living conditions aren't good enough, skilled workers from other parts of the country won't come there to work.

Your corporation will need to be near knowledge resources if it is to succeed. You can sometimes get special help from universities and research centers if it is needed. Nearness to such centers of learning will make it easier to get this kind of help.

Finally, some parts of the country might be less attractive to investors than others. For instance, rural areas, rather than towns and cities, are more likely to be rejected by investors as good places to locate.

Securing Personnel

The human input is the single most important input. Without people to run it, the finest plant in the country with all the other inputs it needs just cannot run by itself. The people who are in charge of locating the plant must find out what types of workers are needed, how many of these there are,

and where they are. If skilled workers are needed but are not living in the location picked out, then local people must be trained to do the skilled jobs, Fig. 72-6. Those in charge of finding the best location for your plant must also find out what the wage rates are in all the places they have picked out. They must also find out what kinds of training schools there are, and how the local people feel about working and going to school to learn new skills.

There are several ways to get workers for the new plant when hiring starts. The most common ways are through newspaper want-ads, employment agencies, and trade journals, Fig. 72-7. Trade journals are often used to get management workers.

After all decisions about the plant location and size, the number and kind of workers, and all other inputs have been made, your corporation is ready to get the *financial* (money) input.

Obtaining the Financial Input

The most common way to get money for a corporation is to sell stock. There are two kinds of corporation stock. They are (1) *common stock* and (2) *preferred stock.* Common stock gives the stockholders the right to share in the profits of the corporation. They have the right to check its books. They have the right to vote for directors. They also have the right to buy more shares when they are offered for sale. If the corporation is *dissolved* (ended), common stock owners have a share in the property of the corporation, if there is any left over after all of its *debts* (bills) have been paid.

Preferred stock usually pays a fixed dividend to its owner. That way, the preferred stockholder is sure of getting his share of the profits before any dividends are paid to the owners of common stock. If there aren't any profits to be shared, then none of the stockholders will get any dividends. In some states, the owner of preferred stock does *not* have a vote in corporation matters, as the owners of common stock do.

Borrowing Money

The corporation can also raise money through the sale of *bonds*. Bonds are certificates, given in return for money, which

Fig. 72-6. The input of knowledge can come through on-the-job training, or through training outside the corporation.

Fig. 72-7. No business can run without people. They may be hired through newspaper want ads, employment agencies, and trade journals.

pay the holder a fixed rate of interest on his money. Bondholders must be paid in full before any stockholders are paid. Unlike stock, bonds have a *maturity date* (date on which the full amount of the bond must be paid to the holder). Bondholders must be paid regularly, but stockholders are paid only when there are profits to be shared with them. A bond does not give its holder any ownership in the corporation. Therefore he does not have a vote in corporation matters. This is not true if the corporation fails to pay the bondholders. Then they may vote on corporation matters.

A third way to raise money to run a corporation is by *notes*. A note is a paper promising to pay back money borrowed from banks, insurance companies, and other loan companies. Notes must usually be paid back in a rather short time. Thus they are used to buy things like parts and standard stock, because these can be quickly turned into a finished product and sold. The sale of the product makes profits to pay off the notes. As long as they pay back these notes on time, corporations usually have no trouble getting new ones when they need them.

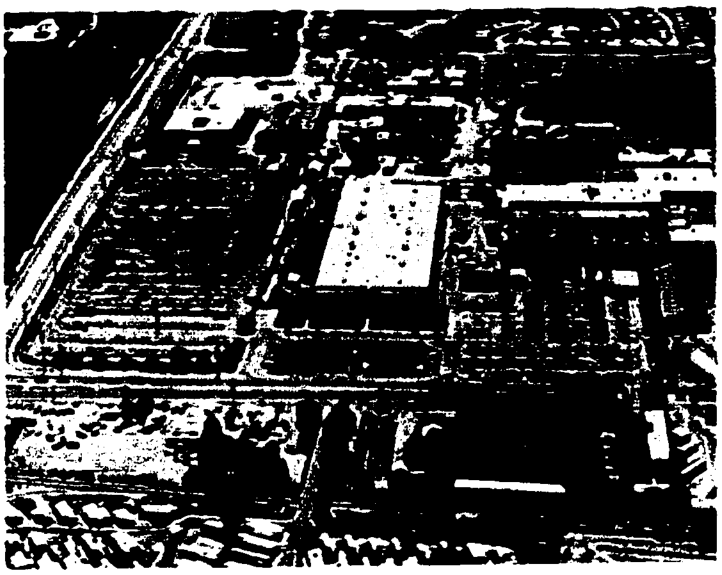


Fig. 72-8. Plenty of parking space, good highways, and nearby railroads make this place a very good location for a manufacturing plant.

Summary

Choosing the place to locate a manufacturing plant is very important if the greatest amount of profit is to be gotten from the sale of the product. Once the needed inputs are listed, it is the job of the corporation to pick a plant location, hire workers, and get parts and raw materials of the best quality at the lowest cost. It is likely that some inputs will be cheaper at one location than at another. All these costs must be studied so that the best location for the plant can be picked.

The cost of taxes and moving parts and materials will probably be higher over the years than the cost of moving people to the plant location. Also, the cost of moving the finished products to places where they will be sold must be thought of in picking the best location for the plant, Fig. 72-8.

Terms to Know

inputs
natural resources
energy
capital
finance
human resources
knowledge
components
cost of manufacturing
availability
continued availability
assembled
vendors
transportation
motor freight
construction
prohibit
tax exemptions
financial
common stock
preferred stock
dissolved
debts
bonds
maturity date
notes

Think About It!

1. In your community, there are inputs that might bring new manufacturing plants in to locate there. Name three specific inputs of each kind listed below:
   a. *natural resources*,
   b. *energy*, and
   c. *human resources*.
2. What are some inputs your community may *not* have that manufacturers would need in order to locate there?

Factors Affecting Plant Location and the Securing of Inputs

- [redacted]
  - Natural resources
  - Energy
  - Capital
  - Finance
  - Human Resources
  - Knowledge
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

READING 73

Designing and Engineering the Product

Suppose that your corporation has been set up and you have located your plant to make and sell desk lamps. Now you are ready to start to design and engineer the desk lamps. You must plan every detail of your lamp before you can start to make any. You must be sure that it will sell as well as other lamps like it. It should be as well-made as the others are. Its price should not be higher than theirs are.

To design your lamps, you will need a number of specialists. These will include some of your top management. A large corporation will usually hire its own staff of product designers, design engineers, draftsmen, model makers, and artists. A small corporation may find it cheaper to hire these people from design consultant firms. The design specialists will work closely with your product engineers and top management, Fig. 73-1. Together they will plan what type of desk lamp you will make, how it will work, and how much it will cost to make. They also will decide on its size, weight, and safety features. They will use survey data gotten by your market research team to help them make some of these decisions.

Fig. 73-1. Product-design specialists work closely with production engineers and top management to plan a new product.

Designing and Engineering

Your marketing and top management people will also study the consumer data survey. They will make decisions based on these data. Then they will send *directives* (instructions) to the designers and engineers that will tell them how the lamp is to be made. The product designers will start with these directives. They will use them to develop your desk lamp.

Suppose you have asked your designers and engineers to design a high-intensity desk lamp. This lamp will be one that can be used at a desk for reading and writing, at a sewing table for making clothes, or at a workbench for close hand-and-eye work.

Your designers will have to make many decisions before they choose the final design of the lamp. For instance, will the lamp use a voltage of 6, 12, or 110 volts? If a 33-cent selenium diode is used with a 110-volt lamp, they can use a bulb with two levels of light intensity. But the 110-volt, high-intensity bulb and its socket cost more than those needed for a lower-voltage lamp. If the lamp is to use 6 or 12 volts, then a stepdown transformer must be used to reduce the *line voltage* (electric pressure that comes into the lamp from the household outlets). The cost of the transformer (about \$2.50) would need to be weighed against

the longer bulb life you would get with the lower voltage.

Cost is not the only thing to think of in picking the *components* (parts) to be used in the lamp. *Efficiency* (how well the lamp will work) and *illumination* (how much light the lamp will give) must be kept in mind for each lamp design. For instance, the illumination and efficiency of 6-volt, 12-volt, and 110-volt high-intensity lamps must be figured out for reading at a desk, for sewing at a table, and for working at a workbench.

The type of power unit used in the lamp not only affects the cost and techniques used to make it, but its *exterior* (outside) design and shape as well. A transformer needs more space in the lamp base than a tiny selenium diode. Since a transformer is heavy, a small base can be used to hold the lamp up. A small base can be used in a slim, modern design. But a lamp that uses a lightweight diode will need a broad or heavy base to hold up the lamp.

In their directives, top managers have sent cost figures to the designers. They will use these figures to help them decide whether the lamp will have a flexible, telescoping stem or a rigid stem. The cost figures will also help them decide how the lamp will be finished (painted, anodized, etc.). They will be able to decide what kind of standard stock to use (wood, plastic, steel, etc.). They will be able to decide whether to use a transformer or a diode as the power unit in the lamp base. Each of these decisions will be based on cost and technical data.

Fig. 73-2. Many sketches and drawings will be made before a design solution is chosen.

Fig. 73-3. Models, mock-ups, and prototypes will be made from drawings. These will help to check the design of the product and get rid of costly mistakes before production starts.

Making Drawings, Models, and Prototypes

The directives from your top managers will help your designers to make *sketches* and *drawings*, Fig. 73-2. *Models, mock-ups,* and *prototypes* will be made from these, Fig. 73-3. Alternate designs will also be made. Rough mock-ups may be made to check some features of the lamp. Models and prototypes may be made after the mock-ups have been checked.

Your product designers and engineers will study these models and prototypes. They will check their safety, their working parts, their ease of *assembly* (joining parts together), and their cost. The prototype will

be a realistic model of what the lamp will look like. It will be easier to see the need to change something in the way the lamp looks or works if there is a realistic model to look at. If problems can be found out in the model, you can avoid costly mistakes during production.

Translating the Design Solution

After the drawings and models have been made, your product engineers and designers will meet with your top management to choose the design that will be used to make the lamps. Your top managers may approve a design, or they may ask for it to be *modified* (changed) in some way, Fig. 73-4. If there are any changes, the modified design will be brought to another meeting to be approved.

After the design has been approved, your engineers will use it to make up *detailed working drawings*, a *production prototype*, *specifications*, and *production schedules*. These data will be used in several ways, Fig. 73-5.

Draftsmen make detailed working drawings that show several views of the lamp and its *dimensions* (sizes). These drawings also list and describe all its parts in detail. The working drawings are used to build the production prototype and to plan production schedules. Technical writers use these drawings to write specifications and prepare instruction manuals, service data for repairmen, and advertising materials for dealers.

Besides designing the desk lamp, your designers will also make sketches of the packages in which the lamps will be shipped or displayed. These packages are often made by a firm that designs and makes containers for other firms. Your own designers may make the package design, or they may only suggest some ideas for it to the designers who work for the container firm. Whatever way it is done, the package is designed before you start to produce the lamps.

Planning Production Schedules

The product designers and engineers may help to plan production schedules. If they are needed, they will go on working with your production planners even after you

Fig. 73-4. This is an over-the-shoulder view of a design solution. It is now ready for management to approve it. Product engineers will then make up detailed working drawings from it for production people to use.

Fig. 73-5. Much data will be used by engineers before they finally decide which parts will be used in the final product.

have started to produce the lamps. If problems come up during production, they will also work with the inspection and quality-control staff to decide on ways to change the design of the lamp.

Time is important in making any product. Your product engineers will help your top management decide how long it will take to plan and design the lamp. They will also help top management decide how long it will take to get the parts, standard stock, machines, tools, and trained workers you will need to make the lamps. They will also work to get the plant set up to produce, package, and ship the lamps to the places where they will be sold.

Before you start to make the lamps, your production-line foremen and a few key production-line workers must meet to decide what machines, tools, and processes will be used to make the lamp, Fig. 73-6. Production-line workers can often see ways to solve problems that might come up only after you started to make the lamps. This way, you can avoid costly time delays later on.

Your production engineers must decide what machines, tools, and workers will be used to make the lamps. They will make up production flowcharts and lists of equipment and material needs along with details of how much time will be needed to work with them. These data will be used to get the plant set up to make lamps. They will also be used to order the right number of parts that will be needed at each assembly point. Most of these decisions are based on the number of lamps that must be made to meet shipping and sales schedules.

Fig. 73-6. Production-line foremen go right to work to find out what tools, machines, and production processes will be used as soon as they get working drawings from the product engineers.

Securing the Components

Getting the *components* (parts) you need to make the lamps is a job for your managers. For instance, suppose that your product engineers have decided what lamp parts will be needed. Now they must help your production managers decide whether it will be cheaper and quicker to make the parts or to buy them. Since your plant will probably not make all the parts you need, you must order some of them from other plants.

Summary

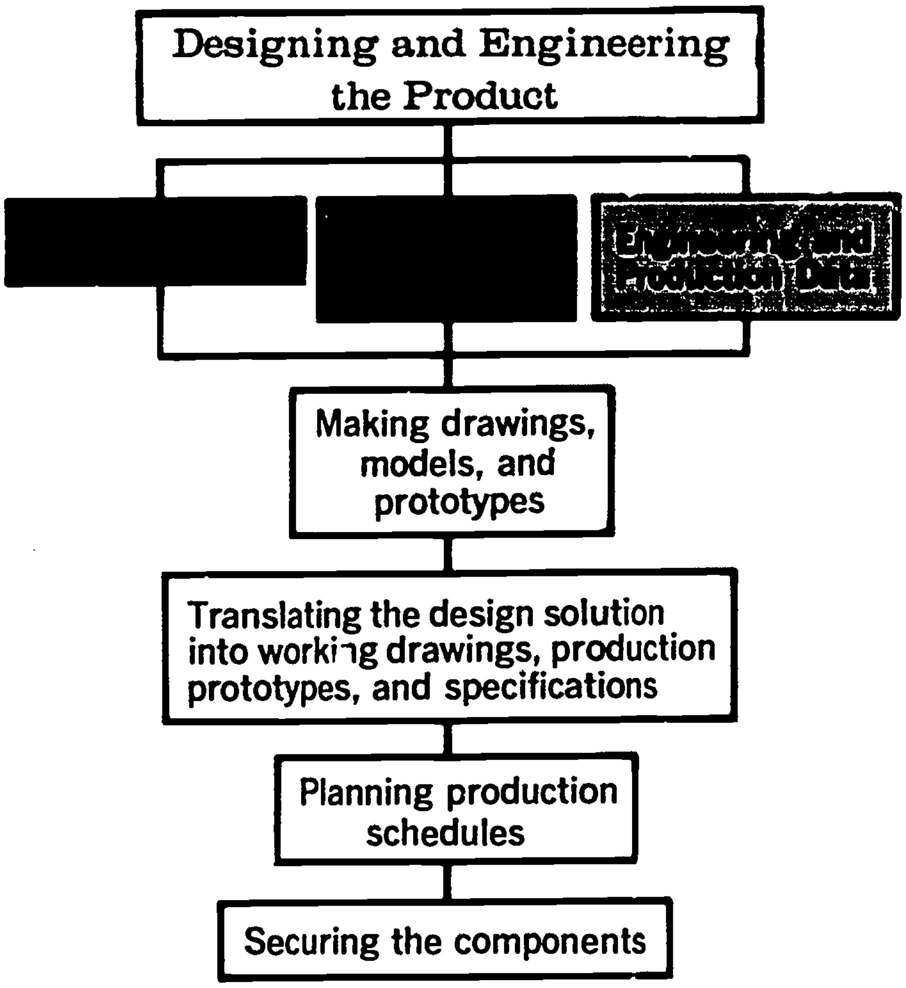
Through designers and engineers, your idea for a desk lamp can become real. Your designers must solve problems of the shape, size, and looks of the desk lamp. Your engineers must solve problems of how the lamp will work. For instance, details of the electrical parts of the lamps must be worked out before you can start to produce them. Every technical detail of manufacturing the lamps must be spelled out. Your next step is to get the plant set up to start producing the lamps.

Terms to Know

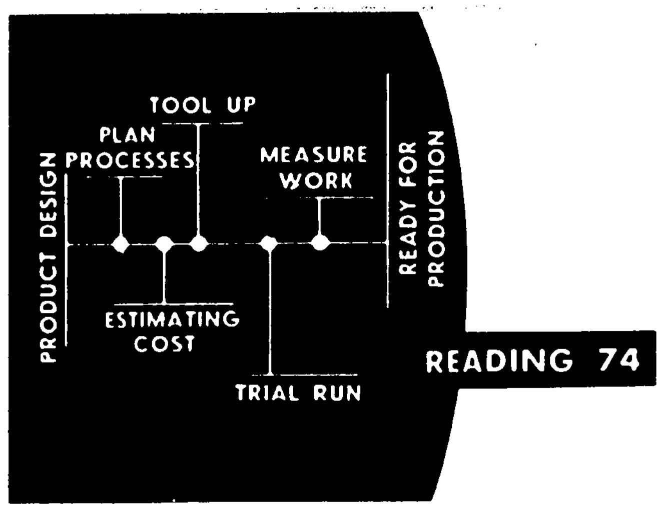
directives	mock-ups
line voltage	prototypes
components	assembly
efficiency	modified
illumination	detailed working drawings
exterior	production prototype
sketches	production schedules
drawings	specifications
models	dimensions

Think About It!

1. Look through today's newspaper and pick out the product which you think was
   a. the hardest to design and engineer.
   b. the easiest to design and engineer.
2. Briefly explain why you picked the products you did for Question #1.



Planning Production Processes



Every *production process* (way of making a certain number of a certain kind of product in a certain length of time) must be planned so that each one will be done at the least cost and in the best possible way. What must your corporation think about before you can get your plant set up to make desk lamps? Who is in charge of this job? How will he decide what process is the best and the cheapest way to do each production job? In this reading, you will learn some of the answers to these questions.

Production Planning

By the time you have reached this reading, your corporation to make and sell desk lamps has been set up. You have picked your plant *site* (location). Your specialists have designed and engineered the desk lamp you will make and sell. Your management knows what the desk lamps will look like. They know how the lamp is supposed to work. They know what materials it is to be made from. They know what parts will be bought and what parts will be made in the plant. They know how much it should cost to make each lamp.

Production planning means to decide on and set up the machines, tools, workers, and materials you need to make a certain number of lamps at a certain *unit cost* (cost of each lamp) by the time they are needed. The *production goal* of your company has been set at 7,000 lamps. They are to be made at a unit cost of $6.43. They should be ready for sale in one year.

Your *production planner* (person in charge of planning every process to be done in the plant) must keep in mind three main factors as he plans each process. They are (1) *volume* (total number of lamps to be made), (2) *cost*, and (3) *time*. Each of these three affects the other two. For instance, if cost did not matter, the planner could ask for any equipment he wanted, no matter how much it cost. If volume didn't matter, he could use very slow machines that didn't cost much to buy. Therefore his job is to choose a combination of men, machines, tools, materials, and techniques so that your plant can make at least 7,000 lamps a year at a cost of no more than $6.43 each, Fig. 74-1.

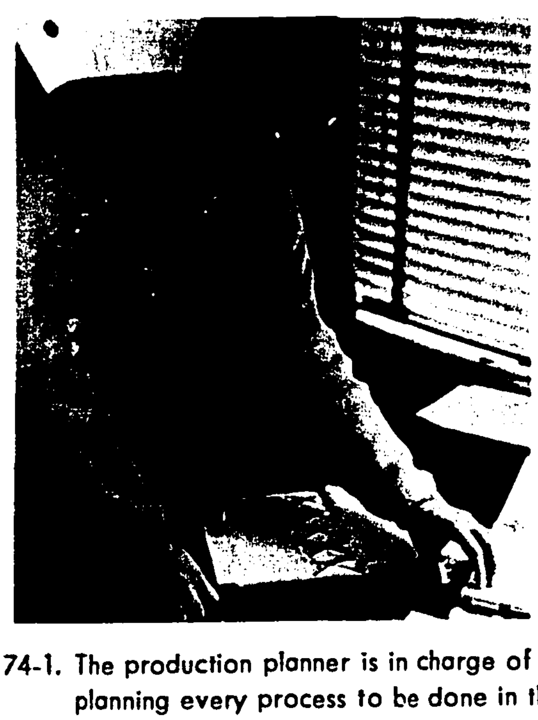


Fig. 74-1. The production planner is in charge of planning every process to be done in the plant. He must make sure that the materials come into the plant, move through it, and come out as finished products in the best possible way.

Production Planning Personnel

Many people work in planning *every* production process. Some of their job titles and duties are given here.

Manufacturing engineer. This person is in charge of planning every process to be done in the plant. He is sometimes called a *process planner*, a *process engineer*, a *production engineer*, or a *production expediter*. As you read more, you will understand why any one of these titles would be correct.

Methods engineer. This man studies ways of doing each production job. He tries to make each one as simple as possible. He tries to find the best possible way to do each job at the lowest possible labor cost, Fig. 74-2.

Work-measurement engineer. This man studies the time and motions it takes to do each production job. He finds out exactly how much work a person can do in a certain amount of time on a certain job. His data can help the methods engineer to find the best possible ways to do these jobs.

Tool engineer. This man picks the tools to use with specific machines. He also works with the process planner on tooling costs. Once the plant has started to make lamps, he is in charge of tool control and tool *maintenance* (upkeep).

Fig. 74-2. The methods engineer will study all the production jobs in the plant. He will try to find the best possible ways to do each one.

Cost estimator. If management must choose between two ways to do a job, the cost estimator is the man who studies each process to find out how much it costs. One process may use more labor than the other. The second one, although it may use less labor, may use more material because some is wasted. He figures out which process will cost less to do when your company is making 7,000 lamps, Figs. 74-3 and 74-4.

All these specialists give your process planner data that he needs to plan every production process. They all work together on production problems. They make their decisions based on their wide range of knowledge and experience.

Types of Processes

What is a *process?* It can be any series of steps that are needed to make a product. Processes that may be used in making a lamp include the following:

Forming. In forming, standard stock material is given the basic shape of a part that is needed. For instance, in a forming process called *casting*, melted iron is poured into a sand mold and allowed to cool. The casting might have the basic shape of the lamp base.

Separating. If one of the lamp parts has to be threaded, the job would mean *removing* (taking off) a little of the metal from the part. Stamping out a lamp shade from sheet metal would also be a separating process.

Drilling refers to a process for making a hole. There are many tools for hand-drilling, and many others for production-line drilling.

Grinding might be needed to remove the rough edges from a formed part and thus bring it down to the right size. Both drilling and grinding are separating processes.

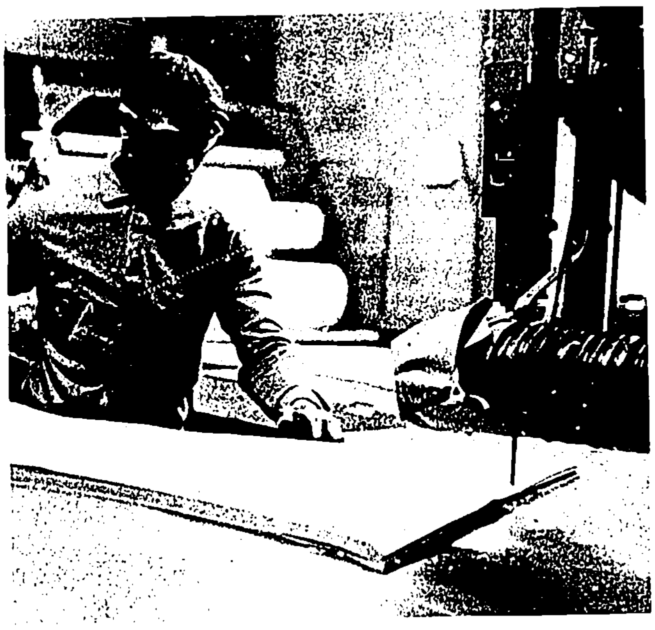


Fig. 74-3. Study the two techniques for cutting lamp shade material as shown here and in Fig. 74-4. The cost estimator studies different techniques for doing each job. Then he can tell management how much each technique costs.

Fig. 74-4. A cutting technique.

Surface finishing. Surfaces that will be seen when a product is in use may be given a *finish* (outer layer) that is very *attractive* (pleasant to look at), or easy to keep clean. Other surfaces may be finished to improve the way they work. Surface-finishing processes include: (1) *painting,* (2) *anodizing,* (3) *sanding,* (4) *sandblasting,* (5) *tumbling,* (6) *electroplating,* and (7) *rubber coating.*

Assembling. This is the job of putting finished parts together to form a product. A lamp would be assembled from a lamp cord, base, socket, stem, switch, shade, and several other parts.

Inspecting. Parts and assemblies may be checked at any stage of their manufacture. A final check is made to see if the product works the way it is supposed to. The product is also checked to see if there are any visible flaws in it.

Process Planning Factors

Almost any part or any product can be made one of several different ways. In order to choose among several possible ways to make it, the process planner tries to answer these questions:

Availability. Does the plant already have the machines and tools to make it, or will they have to be bought?

Capacity. Will the process make enough products to meet sales needs? Will it make any extra, in case we sell more than we thought we could?

Quality. Can the process make parts of *acceptable quality* (good enough to sell)?

Personnel. If the plant is new, can trained workers be hired to run the machines? If the plant is already running, can the workers now on the job be used to make the new product? What special training must the workers have?

Materials. What kind of materials can be used? If the machines will make lamp parts out of steel, will they also make aluminum parts?

Overall economy. Will there be high maintenance and repair costs? What will the power needs be? Will the machines *depreciate* (lose value) a great deal each year?

Automation. Should the production line be automated? The planner must decide if the lower labor costs will pay for the higher machinery costs. In general, automation is cheaper for making large numbers of products than it is for making small numbers.

Material handling. What are the best and cheapest possible ways to handle raw materials, partly finished lamp parts, and finished lamps? There are many kinds of material-handling tools and machines. Your choice will depend partly on your choice of processes. You should choose the ones that will not need a great deal of material handling.

When these questions have been answered for each possible process, the planner can choose the best ones and the tools and machines needed to do them, Fig. 74-5.

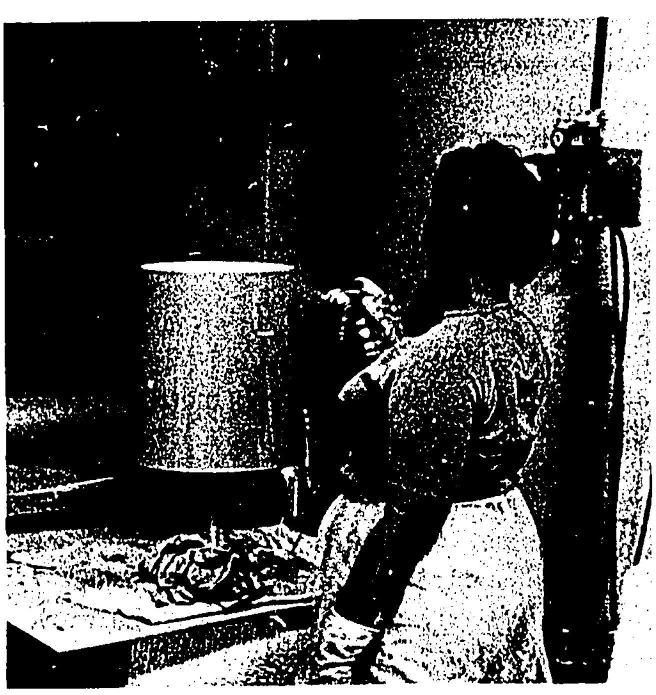


Fig. 74-5. Each type of process is studied carefully. The best process is the one that can be fitted into the total plan of production. Many questions must be answered before the best process can be chosen.

Process Planning Documents

After process planners have picked the processes to use, their plans must be set down on paper for the production staff to use. Several *documents* (official papers) are needed.

Flowchart. The flowchart shows where each process will take place. It tells what tools and machines should be used. It shows the movement of raw materials, partly finished parts, and finished products.

Routing sheet. The routing sheet tells how materials and parts will be moved from one process to the next.

Job descriptions. These tell what job each person on the production staff will do.

Production schedule. This schedule tells the foreman how many lamps should be made in a certain length of time. For instance, it might call for making 135 lamps each week. The schedule can be changed each week, or even each day, if sales increase or decrease.

These documents help the production staff to make an acceptable product on time and at the lowest cost.

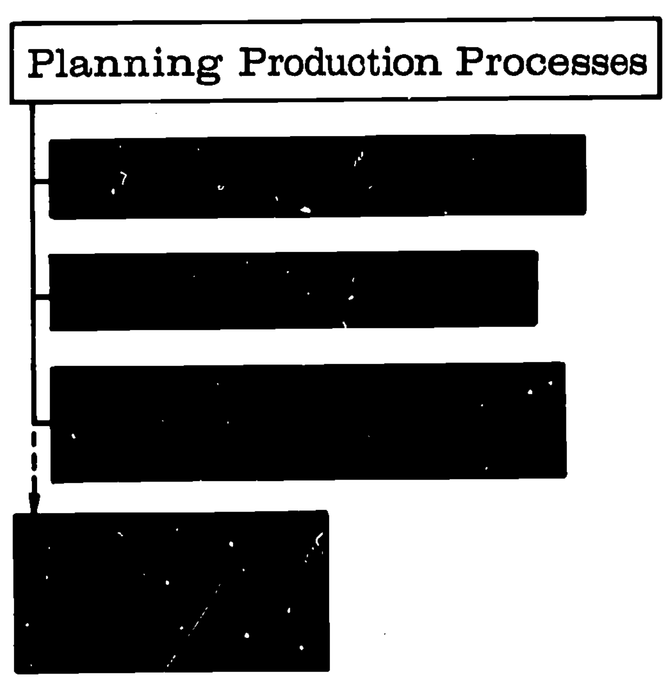
Summary

The process planner is always looking for the best possible ways to make his product. He must study each step of production, choose the right process for it, and decide how many jobs there are in each one. He picks the best ways from all the ones that are possible to do in his plant. He picks the right tools and machines and how they are to be used.

He must help lay out the plant space he needs, and must see to it that he gets the tools and machines he needs. This will help management to hire and train the workers needed to run these machines and to do these jobs. All of these activities help increase manufacturing efficiency. In the next reading, you will learn how to set up the plant for production.

Terms to Know

production process
site
production planning
unit cost
production goal
production planner
volume
cost
time
manufacturing engineer
process planner
process engineer
production engineer
grinding
surface finishing
finish
attractive
painting
anodizing
sanding
sandblasting
tumbling
electroplating
rubber coating
assembling
inspecting
availability
production expediter
methods engineer
work-measurement engineer
tool engineer
maintenance
cost estimator
process
forming
casting
separating
removing
drilling
capacity
quality
acceptable quality
personnel
materials
overall economy
automation
material handling
documents
flowchart
routing sheet
job descriptions
production schedule



Think About It!

1. Look at your pencil or pen. List the processes used in the manufacture of this product.
2. Write a schedule for the activities (processes) you did this morning in getting dressed and ready to go to school. Study the schedule and see where changes can be made to increase the efficiency of the process. Follow the new schedule tomorrow and compare the efficiency.

READING 75

Establishing Production and Quality Control

In last semester's readings, you learned how important it is to control the production and quality of manufactured goods. *Production control* makes sure that the right material is used in the right amount at the right time and place. *Quality control* makes sure that the product will (at all times) meet the standards that have been set up for it.

In this reading, you will learn more about the kinds of controls there are in the production of your company's desk lamps.

The Results of Good Control

A good system of production control will have these results:

1. The right *production rate*. This means that the right number of lamps will come off the assembly line each day, Fig. 75-1.

Fig. 75-1. Good production control will make sure that the right number of lamps are made.

2. The best possible use of *manpower*.
3. The best possible use of space and *equipment*.
4. The best use of materials, with as little waste as possible.

The right production rate is the one that will make just the number of parts that are needed to make a certain number of lamps. For instance, the desk lamp is made up of a base, a stem, a shade, a socket, a switch, and some wires. One of each part must be at the right place at the right time, so that one complete lamp can be *assembled* (put together) without delays. If five bases, five stems, five shades, five sockets, the right number of wires, but only *one* switch get to the assembly point, then only *one* lamp can be put together. Therefore the production rate for each part must be worked out so that the right number of each part is always there at the right assembly point when it is needed.

Some parts may be bought from other firms. Therefore the control system must make sure that the right number of *purchased* (bought) parts are delivered at the right time.

To make the best possible use of manpower on a *production line* (fabrication and assembly line), it is most important that the right number of workers are doing the right jobs, Fig. 75-2. For instance, if there are not enough workers to do a certain job, then the machines may sometimes stand idle. If machines are idle, then time is lost. If time is lost at one work station, then time will be lost at all the others too. The more time that is lost, the more it costs to make each lamp. On the other hand, if there are too many workers on a certain job, they

may get their work done too fast. They would lose time waiting for more parts to get to their work station. This kind of lost production time also makes it cost more to produce each lamp.

Fig. 75-2. The right number of workers must be working at each process. A slowdown at one work station will cause all others to slow down.

Fig. 75-3. Workers should be working on jobs that they can do. If a worker has been trained for, and is being paid for, a job that needs a high degree of skill, he should not be working on a low-skilled job. This is wasting the corporation's money.

If workers are put on jobs they are trained to do, this is another way to keep costs low, Fig. 75-3. For instance, if a man is being paid the wages of a skilled worker, he should not be doing a job that an unskilled worker could do. He costs too much to be used this way. On the other hand, an unskilled worker on a job that a skilled worker should do also costs too much. He may damage or destroy parts.

Production Control

There are several kinds of production control you can use to set up the right production rate and to use workers, space, machines, tools, and materials in the best possible way. They are (1) *order control,* (2) *inventory control,* (3) *quality control,* and (4) *block control.*

Order control makes sure that the right number of lamps are made to fill the orders from customers, Fig. 75-4. When a customer sends in an order, a *bill of materials* (list of all the materials in the right amounts that will be needed to make up the customer's order) is made out, *route sheets* (how the

Fig. 75-4. Production should be geared to the rate at which you get orders from customers. Too slow a production rate will keep too many customers waiting. This in turn can hurt your future sale of lamps.

materials and parts will be moved from one work point to the next) are made up, and production is *scheduled* (showing times for each process that is used to make the customer's order).

To start making the lamps for the customer's order, standard stock like the metal for the base and stem of the lamp, as well as parts already bought and stored, must be sent from the warehouse to the machines where they will be used. At the same time, orders must be sent out for any parts or materials not bought and stored *in advance* (ahead of time).

Inventory control must make sure that standard stock and parts not made in the plant are always on hand when they are needed, Fig. 75-5.

Quality control must make sure that finished lamps meet all the specifications set up by the designers and engineers, Fig. 75-6. To *maintain* (keep up) the quality of the lamp, some lamp parts and subassemblies are tested. Finished lamps are *inspected* (checked) to make sure they look and work as they are supposed to.

Your plant may make lamps in several different styles that use many common parts. These lamps would be made under *block control.* This means that the *blocks* (groupings of each style of lamp) must be controlled, Fig. 75-7.

Fig. 75-6. Quality control makes sure that the lamp meets the standards set up by designers and engineers. The tests made on the lamps will help to set up the terms of the company's warranty.

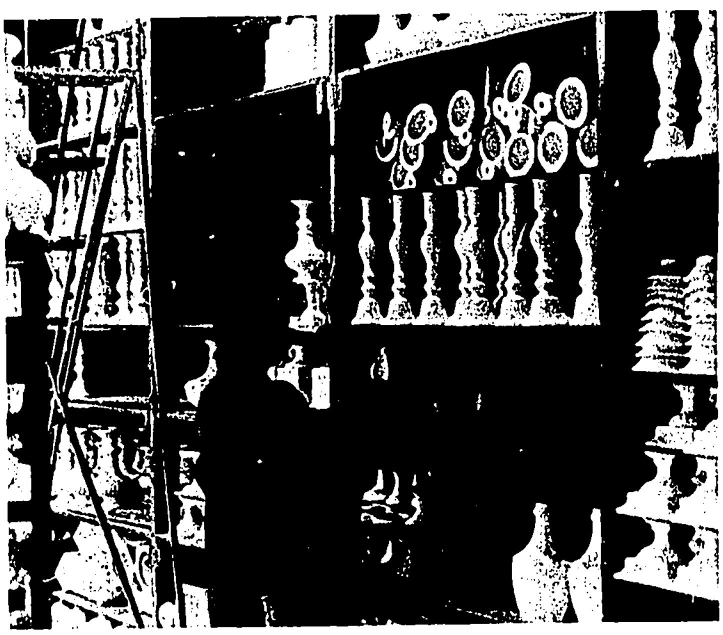


Fig. 75-5. Inventory control makes sure that the right number of each part of the lamp is on hand. Forgetting to order any one part can cause a whole plant to shut down.

Fig. 75-7. Block control is the control of different groupings of a product. Certain styles of lamps may need higher control standards than others do.

Establishing a Production Control System

Someone in your management must be in charge of each kind of control. Some kinds of *data* (information) must be reported, in written form, for each control job. The best possible ways to store and *retrieve* (get back) all these data must be set up. To set up all these kinds of production control, a great deal of careful planning must take place.

Several steps must be followed to set up a production control system for your desk lamp plant. First, the system should use the layout of your plant in the best way. At this point in these readings, you have already picked the best *site* (location) for your plant. In picking this site, you have already thought about where your customers and *vendors* (sellers of the parts and materials you need to make lamps) are located, what the best ways are to ship goods to and from your plant, and how many skilled, unskilled, and trainable workers you will be able to hire.

Your production manager will work with your personnel manager to find out what worker skills you need to run the plant. You may need to set up some type of training program for the workers you will hire.

You must make up lists of materials and send them out to your vendors. You must be sure that there are delivery dates on all these orders. You must see to it that materials will be stored in the best way so that they can be moved smoothly to the points on the assembly line where they will be used.

You must set up production schedules for each worker and each machine. You must check again later to make sure that these schedules can be met. Before your plant can run smoothly, you may have to change a lot of things.

Today, some plants use an electronic computer to set up production lines. If you want to use this technique, you will need someone who knows every step of production, and someone who can translate these steps into computer language. When these steps are fed into a computer, it can often show you the points in a "make believe" production line where you might have problems. This technique is called *simulation.*

Quality Control

To control product quality, your managers should ask themselves these questions: Have we made as good a desk lamp as we can for the price we are selling it? Are we making a better lamp than other lamp companies? Will our customers be pleased and keep buying our lamps?

Fine products cannot be made from poor materials. To make sure that the quality of materials and parts coming into your plant is good, your managers must set up specifications for these *inputs.* When you order light switches or tubing, the order should state the exact details of size, how they must work, or how long they must last. Some way should be set up to check these incoming materials as often as possible. In this way, you will be able to control the quality of materials that go into the lamp.

Standards should also be set up for each job done in the plant. Some of these standards will refer to measurements. For instance, if a part is supposed to be 14 inches long after it has been *sheared* (cut), a difference of $\frac{1}{16}$ inch may be all right. A drawing will show the size as $14'' \pm \frac{1}{16}''$. (This is read as 14″ *plus or minus* $\frac{1}{16}''$.) This small difference of $\frac{1}{16}$ inch is called a *tolerance.* Another kind of tolerance shows how far a tube may be *out of round* (how far it can differ from a perfect circle). Tolerances are a kind of language that designers, engineers, production workers, and quality control men use to talk to each other, and to agree on product quality.

Other standards for a desk lamp will refer to cracks, dents, or scratches that happen while the lamp is being made. If the same kind of damage happens often to one part,

a quality control man will look for the cause. He may find that the material is too thin or too soft. He may find that a machine is not working right, or that the worker is not running the machine right, Fig. 75-8. The damage may be happening as the part is picked up, moved, and set down at another work station. Whatever the cause, there must be someone who makes sure that it is corrected. Some way to report these problems to him and some way for him to correct such problems must be set up in the quality control system.

Quality standards for your desk lamps should be set up for each *bonding* (joining) process. For instance, it is quite likely that some of your desk lamp parts will be joined with solder. It is also likely that the soldered parts will be hidden when the lamp is finished. Quality control should check the soldered parts to make sure that the bond is strong. All glued bonds and mechanically fastened parts should also be checked before the lamp is finally put together.

There should also be a final check on how the lamp looks and works. Each lamp should be looked at before it is packaged. The electrical system should also be checked to see if it works well.

Not every lamp can be taken apart and *completely* checked and tested. If this were done, you would need as many inspectors as you did workers. Of course, this would cost too much. Quality control checks are done by taking a *random sample*, Fig. 75-9. For instance, every twenty-fifth lamp might be completely tested to see if the lamp and all its parts meet the standards they should. There are mathematical ways to decide what percentage of the lamps will meet the standards, based on the results of testing and random sampling. Your company will probably agree to replace any lamp that leaves the plant with any poorly made parts. Therefore you must be sure that very few *defective* (poorly made) lamps are shipped out. For your desk lamp, your managers may decide that the quality of lamps is good enough if no more than three percent of all the lamps are likely to be defective.

There is one other type of testing that is usually done. It is called *destructive testing*. For instance, a lamp might be dropped from a desk over and over again to find out how many times it can be dropped before it stops working or falls apart. From the results of destructive tests, you will be able to

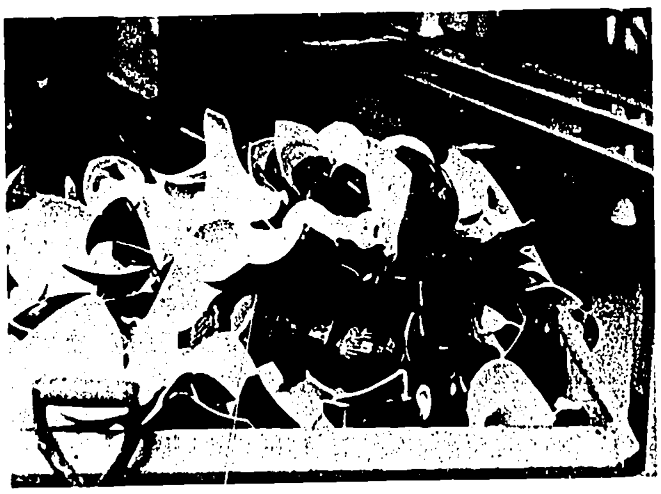


Fig. 75-8. Quality control checks may find out that a machine is not working right. The broken lamp bases seen here cannot be used and must be thrown out. This waste of time and material can be very costly.

Fig. 75-9. The lamps may be checked by taking a random sample. This means that the total run of lamps may be accepted or rejected on the basis of a complete check of only a few lamps in the total run.

set up the terms of your company's *warranty* (guarantee that the lamp will work), Fig. 75-8.

Inventory Control

There are many jobs in an inventory control system. A good system always has enough of the right materials on hand at the right time. Extra standard stock materials take up space and tie up *capital* (money to buy land, buildings, tools, and machines). Therefore inventory control must make sure that there are just enough materials and parts on hand to be used. They must also make sure that these are replaced as they are used up.

Tools and machines are an investment of capital dollars. If there are too many machines for a job, then some of them will not be used. If a machine must stand idle while you wait for a replacement part, a whole production line may be shut down. Therefore inventory control must keep enough tools and replacement parts for machines on hand so that production lines can keep going.

Inventory control men must also check on how many parts are being used in the production of the lamps. More parts must be stocked to replace parts damaged during assembly and also to replace parts for the customers.

Inventory control men must also tell the production staff if there are too many finished desk lamps in the warehouse. If this happens, your salesmen will have to sell more lamps. If they can't, then you may have to cut down the number of lamps being made on your production line.

Summary

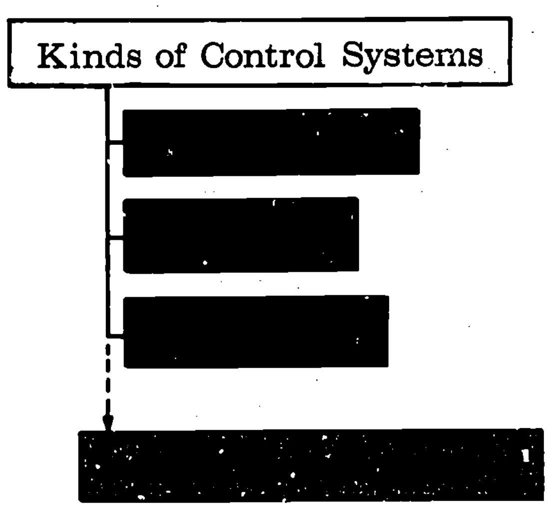
There are three basic kinds of control systems that must be set up in your lamp plant. They are (1) production control, (2) quality control, and (3) inventory control. Each has its own special jobs to do, but they must all work together. These control systems help increase production efficiency. Your managers depend on these control systems to help make lamps in the best possible ways, so that your company will make a profit. These control systems must be set up before you can start to make desk lamps.

Terms to Know

production control
quality control
production rate
manpower
assembled
purchased
production line
order control
inventory control
block control
bill of materials
route sheets
scheduled
in advance
maintained
inspected
blocks
data
retrieve
site
vendors
simulation
inputs
sheared
tolerance
out of round
bonding
random sample
defective
destructive testing
warranty
equipment
work in progress
finished goods
capital

Think About It!

1. You can buy ballpoint pens for 10¢ and for $3.00. What differences in *quality control* are there in the 10¢ pen and the $3 pen?
2. What are some *production control* problems that a large clothing manufacturer might have?



READING 76

Making and Combining Components and Assemblies

At this point in these readings, you have already formed your corporation to make and sell desk lamps. The lamp has been designed. Every production process has been picked out. Your plant has been laid out. You have decided to make some of the *components* (parts) of the lamp in your plant. The rest will be bought and shipped to the plant already made, Fig. 76-1. Standard stock materials have been ordered. Through a trial run, possible delays or problems have been found and taken care of. You are now ready to start full-scale production of desk lamps. All the parts will be *assembled* (put together) into finished lamps on your production lines. The finished lamps will be shipped to your customers, or stored in your warehouse for future sales.

In this reading, you will learn more about *forming, separating,* and *assembling.* You will find out how each process is used to make desk lamps. You will also find out how and why production schedules are changed.

Selecting Production Techniques

In an early stage of planning, you had to decide what production *techniques* (ways to do something) to use to make your desk lamps. You could use techniques that are *mechanized* (done by machines that are run by men) and *automated* (done by machines that are run by other machines). You could use techniques that are *manual* (done by men by hand). The number of lamps to be made in order to earn a certain profit is what you used to help you decide. If you were going to make a large number of lamps, then the mechanized and automated tech-

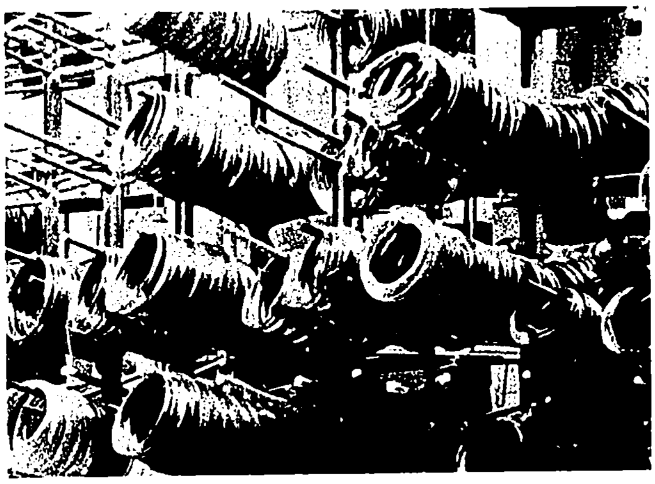


Fig. 76-1. Some parts for the lamp will be bought from other companies. The rest of the parts will be made in your own plant. These wire rings were bought to be used as parts in the lamp shade assembly.

Fig. 76-2. Manual production techniques are best when you are making very small numbers of lamps. But if you increase the number of lamps you make, it will be cheaper to use automatic equipment.

niques would be the best ones to use. If you were going to make a very small number of lamps, you would want to use manual techniques, Fig. 76-2.

You have decided to make a small number of lamps for a short period of time. It would be too costly to use a lot of mechanized or automated techniques. Thus you chose to use manual techniques to make your desk lamps.

Manufacturing Components

Also in an early stage of planning, you had decided that the base, shade, and stem were the three parts of the desk lamp that would be made in your own plant, Fig. 76-3. You found that other companies were better equipped to make some of the standard parts like the power cord and plug, socket, switch, and fasteners.

The design of your lamp will be studied here, in order to see how each process is used to make each part. You are going to use manual techniques to make the base, shade, and stem of the desk lamp. A large modern plant would use mechanized techniques. You will see how both kinds of techniques can be used to make these parts.

The base of the lamp is made from sheet metal standard stock. It is done in the following *sequence* (order) of steps.

Laying out the pattern. When manual techniques are used, a hardboard *template* (pattern) is laid over the sheet metal, Fig. 76-4. The outline of the part and the locations for holes are traced onto the metal surface with a scratch awl. When mechanized techniques are used in industry, this step is not needed.

Shearing. Tin snips can be used to *shear* (cut) each part to the right size and to cut out notched edges to show where the bend lines are supposed to be. In industry, this would be done on a punch press that used matched dies. Special cutting dies would have been designed to shear the sheet metal stock to the right size and shape. All holes and slots would be punched at the same time. This would make sure that all the joining parts would fit together. Then the stock would move on to another press that would form the sheet metal to the right shape.

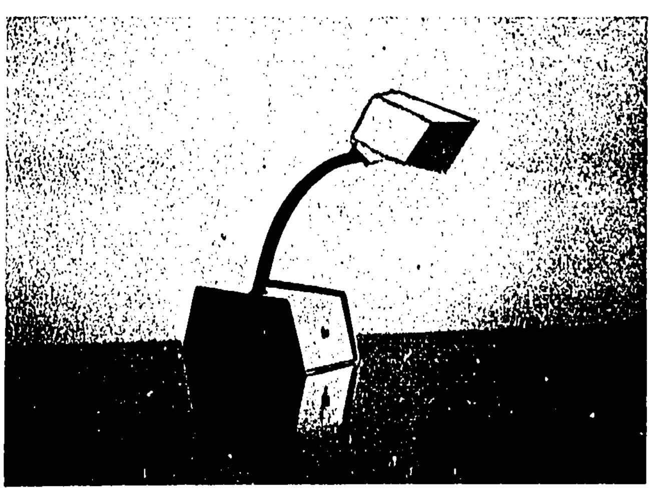


Fig. 76-3. This desk lamp is made up mainly of a shade and a base, both of which are made of sheet metal. The stem is made of a piece of metal tubing.

Fig. 76-4. A template may be used to mark each piece to be cut from sheet metal. This will make sure that each piece will be the same size and shape.

Drilling holes. In hand work, a hand drill (or punch) or a portable electric drill is used to drill all rivet and screw holes. It is also used to start the rectangular holes for the switch on the front of the lamp base. In industry, all holes are cut at the same time as the part is sheared to the right size.

Filing. The rectangular holes are finished by hand with a file. On a punch press, the matched dies make the finished holes.

Bending. Each part is bent by hand on a box-and-pan brake. The notched edges are used to locate the bend lines. In industry, bending is done on a press.

Temporary assembly. The top and bottom of the base are put together to check the fit. If they fit together well, screw holes in the top part are used to locate and mark holes in the bottom part. The parts are then taken apart, and the marked holes are drilled, Fig. 76-5.

The stem f\ he desk lamp is made from aluminum tube stock. It is done in four steps.

Cutting. A hacksaw is used to cut the stock by hand. In industry, a band saw is used to cut the stock to the right lengths.

Bending. For either manual or mechanized work, a bender is used.

Drilling. There must be a hole near each end of the bent stem so that the lamp cord can pass through the tube. Screw holes are also needed. For hand work, a hand drill or a portable electric drill is used. In industry, a drill press is used.

Slotting. In hand work, a slot is filed in the stem. In industry, this is done by a milling machine.

The surfaces of all these base and shade parts, as well as the stem, must be gotten ready to be coated with paint.

Surface preparation. In hand work, each part is sanded with *abrasive* (rough) paper. In industry, sandblasting may be used. The surfaces may also be chemically cleaned in a pickling solution.

The design also calls for a short piece of wooden dowel rod. This part is made in one step.

Sawing. The dowel rod is sawed to the right length by hand with a backsaw. In industry, a band saw is used.

Assembly Processes

Actually, there is no set order in which *assembling* (combining) must be done. For instance, you might combine the stem and the base of your lamp first. But the cord could also be threaded through the stem and wired to the socket first. You have already made your decisions when you planned each production process. The following steps for assembling the parts of your desk lamp may help you see how this process could be done.

First, the stem is attached to the dowel rod. Next, a bracket is fastened to the shade with a riveting gun, and the stem is then bolted to the bracket. Next, the stem is put through the top of the base. The cord can now be threaded through the base and stem, and then wired to the socket, Fig. 76-6. The socket is now fastened to the top of the stem with a bolted bracket. Next, the

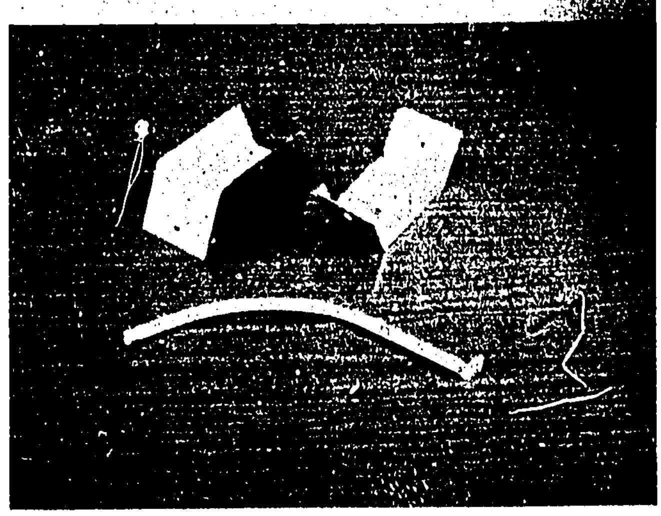


Fig. 76-5. This desk lamp base is made from two sheet metal parts. All of the holes for fastening it together are already drilled in it. The stem is also shown.

switch is installed in the base, and the electrical connections are made. The stem is then fastened to the bottom of the base. The plug is next attached to the cord, and felt is put on the bottom of the base. Finally, the trim is painted onto the lamp by hand, Fig. 76-7.

This is just one sequence of assembly that might be followed for a lamp that is combined by manual techniques.

Some of these parts might have been assembled by mechanized techniques. For instance, there is a machine that can fit and join matching parts of the lamp shade for spot welding.

The line cord, switch, socket, and wiring would probably be combined by hand. The power cord and plug would probably be bought as a single, molded part, rather than as two separate parts.

Production Schedules

On your production line, only one kind of lamp is being made at any one time. If the sales of this lamp are steady enough and high enough, your managers will schedule *continuous production* of this lamp.

You decided during an early stage of planning that a single lamp style would be made. But it is possible that one of your customers may order a small number of high-intensity lamps with a slight change in design. For instance, he may order 200 lamps with two light intensities. Since this is a small order, you may be able to custom-make these lamps. You may need more workers, or you may have to shift some workers to different work stations because the lamp design has been changed. You will surely have to order some new parts, like transformers, selenium diodes, sockets, and switches.

If the number of sales of these custom-made lamps is not high enough for continuous production, you may have to run *intermittent production.* This means that you will stop making your standard lamp while the custom-made lamp is produced.

Modifying Production

You may have to *modify* (change) the design or production techniques if your qual-

Fig. 76-6. This worker is wiring the cord to the bulb socket on a table lamp. A bin of precut electric cords is on a table beside the lamps.

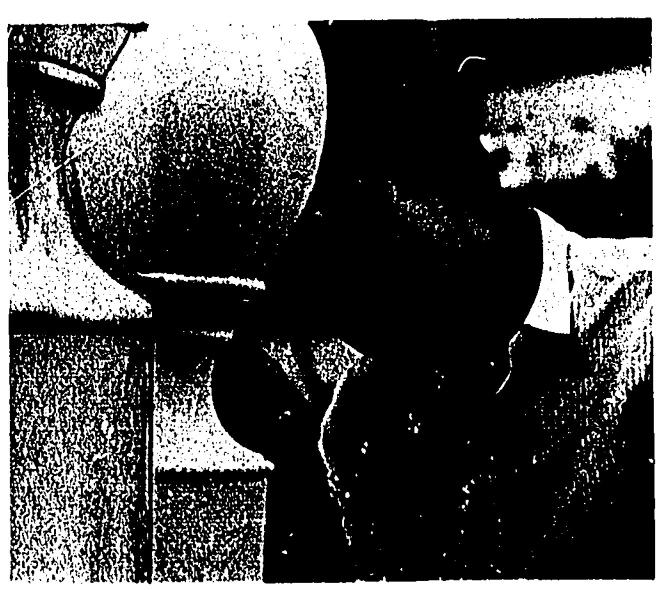


Fig. 76-7. The final trim on this lamp is painted on by hand.

ity control staff finds poorly made lamps, Fig. 76-8. They may find that the aluminum rivets or the spot weldings do not *bond* (join) the metal shade tightly enough to the lamp. They may find that there is an electrical ground in the base or the stem of the lamp. This would make the lamp unsafe to use. Parts that are *defective* (poorly made) or broken during assembly must be thrown away. This is a waste of labor and materials, Fig. 76-9.

These problems will be studied by your production engineer and your quality control staff, and maybe your production foremen. They will solve the problems and ask for changes in the lamp design or in some production process.

Time and motion studies may show that workers are not being used in the best ways at their work stations. Jobs and duties of some workers may need to be changed after you have started to make lamps.

Your production control manager must study each production process so that he can find out whether parts, subassemblies, and finished lamps are getting done on time. If they aren't, he must report this to someone who can find the trouble and correct it.

Summary

If desk lamp parts are made by manual techniques, the separating processes may include shearing, drilling, filing, sawing, and sanding. In industry, some of these processes won't be used because the work can be done by matched dies on a punch press. One kind of forming process (bending) will be used.

All of the surfaces of the lamp parts will be coated with paint. To get them ready for painting, the parts are sanded by hand, or sandblasted by machines.

There is no set order in which the lamp parts must be assembled. These decisions must be made in the early stages of production planning.

Whether you will plan continuous production or intermittent production depends on the number of lamps you are selling. If the number is steady and high enough, you will make a single lamp style all the time. If the number is low and orders do not come in all the time, then you will plan to make one lamp style for a while, and then stop making it when you get a special order for a slightly different lamp style.

Fig. 76-8. You may have to modify production while work on the lamps is still in progress.

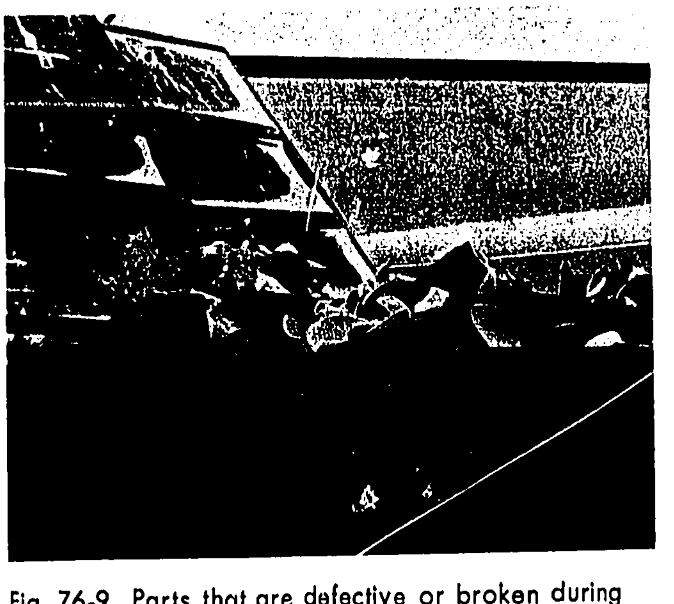
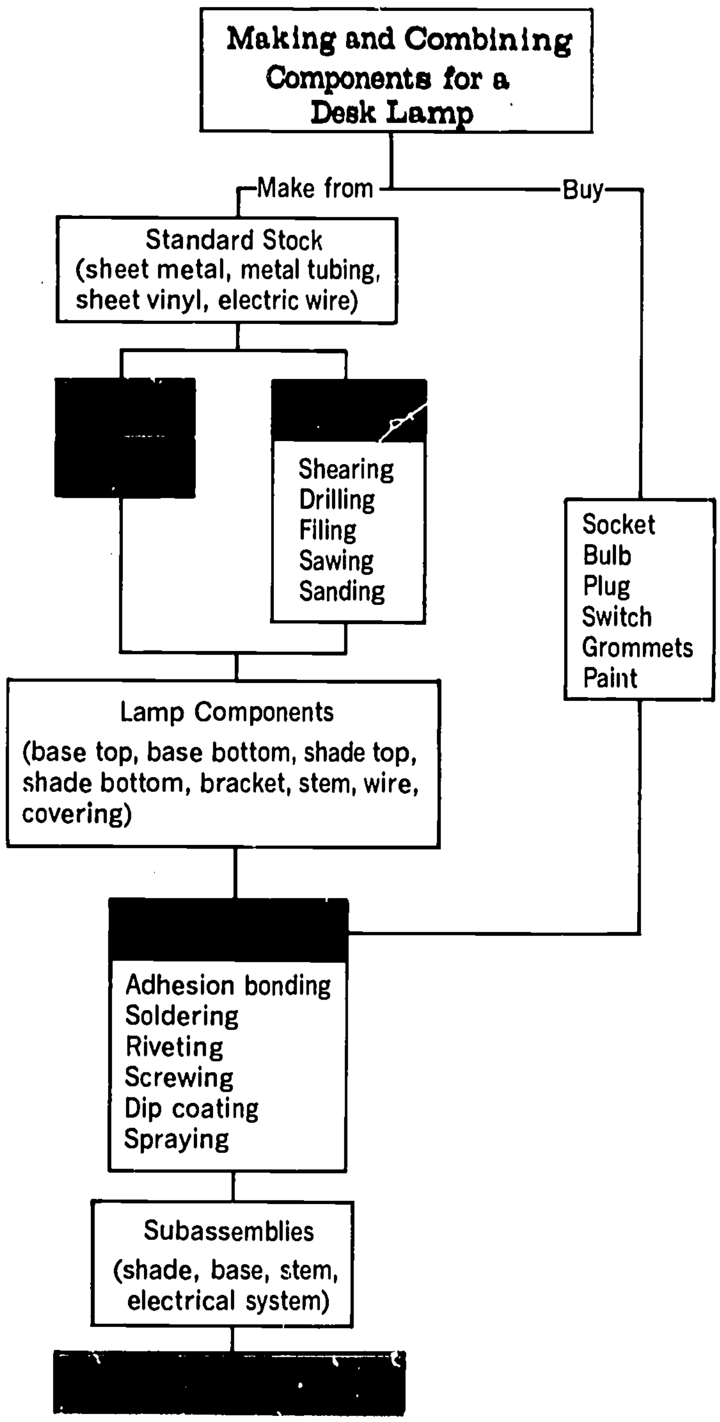


Fig. 76-9. Parts that are defective or broken during the assembly process must be thrown away. This is a waste of labor and materials.

You may have to change the lamp design or some production process if quality control finds poorly made or broken parts coming off your production line.

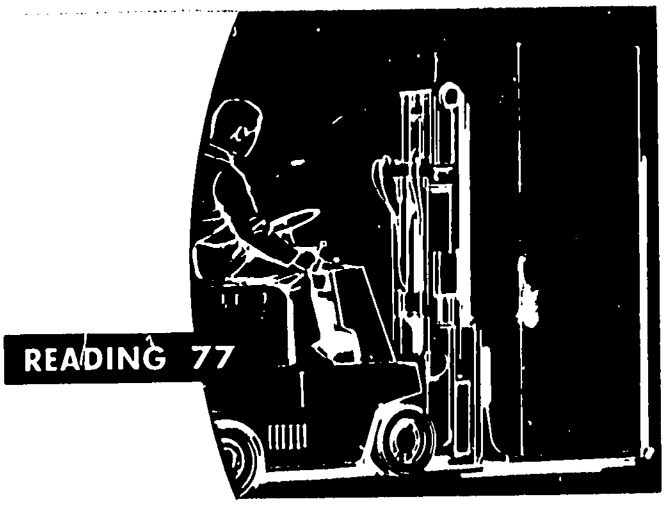


Terms to Know

components	drilling holes
assembled	filing
forming	temporary assembly
separating	cutting
assembling	bending
techniques	drilling
mechanized	slotting
automated	surface preparation
manual	abrasive
sequence	sawing
laying out the pattern	continuous production
template	intermittent production
shearing	modify
shear	bond
	defective

Think About It!

1. Look at a table lamp and identify what forming, separating, and assembling processes were used on the shade, harp, body, and electrical circuit.
2. What are some of the problems the manufacturer of commercial passenger airplanes must solve in *assembling* the different parts and subassemblies?



Arranging for Distribution and Sales

Now there are finished desk lamps coming off your plant's production line. They must be packaged in a form that will get them from your plant to the *consumers* (customers). You should make plans to *advertise* them (make people aware that they are for sale). You should make plans to *market* them (sell them). You should make plans to *distribute* them (ship them to wherever they will be sold). In this reading, you will learn how to make these plans.

Product R & D

Most lamps are made in one place and used in another. A package must be made to hold each lamp as it is moved from one place to the other. To make a package for a desk lamp, you must go through the same steps of research and development as you did to make the lamp. These steps must be *planned, organized,* and *controlled.*

In large corporations, many department staffs may work together to develop the package for the product. The legal staff will help decide what is said on the label of the package. The research staff will help decide whether a planned package is strong enough to last if it is handled roughly. The traffic staff will know about shipping *regulations* (rules). The production staff will help, if the package is going to be made in the plant. The purchasing staff will find out where any odd-shaped kind of package can be bought. The sales and advertising staffs will help decide whether the design of the package is pleasing to look at.

A package is supposed to (1) *contain* (hold), (2) *identify* (name), (3) *protect* (keep from damage), and (4) *display* (show) the product. See Figs. 77-1 and 77-2. Many products are first packaged in single units. Then they are packaged in larger units to make them easier and cheaper to handle. For instance, each desk lamp is put into its own package. Then a dozen of these packaged desk lamps may be packed in one large carton to ship them. Some companies make their own packages. Many others buy them from those companies that make and sell packages and containers.

To design a package, you must think about its size and shape. You must also think about its *performance* (how strong and long-lasting it should be). You must think about its *appearance* (how pleasing it looks). You must think about its *maximum*

Fig. 77-1. The plastic is placed on these lamps not only to protect them from dirt, but also to allow them to be displayed without taking the package off.

cost (the most it will cost to make without cutting down the profit you will earn on the product itself). A good package is one that looks good and does what it is supposed to do: contain, identify, protect, and display the product. How good a package for a desk lamp looks would not be too important, since a lamp is displayed without its package.

Fig. 77-2. The package must be designed to keep the lamp from breaking while it is moved from one place to another. The cardboard baffles in this carton will protect the lamp from the shocks that happen as the carton is handled.

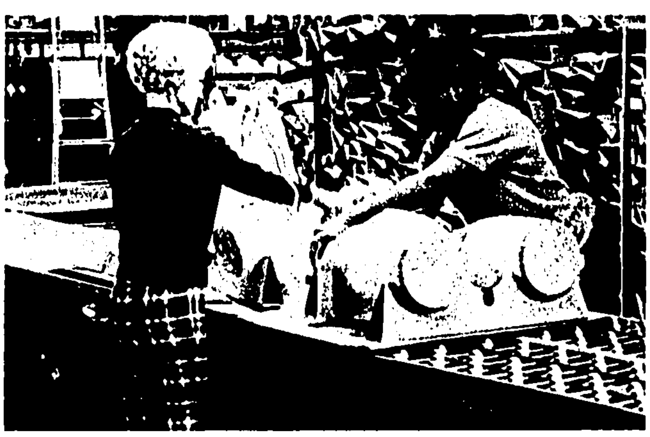


Fig. 77-3. You must get your plant ready to make and combine the package just the way you did for making the lamp. You must pick the best possible processes for making the package, just the way you did for making the lamp.

Engineering the Processes

After your designers have come up with several package designs, your top management will approve one of them as the package your lamps will be packed in. From that point on, the steps used to develop and make the package will be like those used to develop and make the lamp itself.

Your production engineer must pick the safest, easiest, and cheapest way to make the package. He will try to use the workers, materials, machines, and production space you already have. He will try to use automatic machines to make the package, if he can. Modern packaging machines can make different sizes and styles of packages very quickly. In this way, the cost of making the package for the lamp can be kept very low.

Preparing the Plant for Production

If the package is to be made at the same plant that makes the product, there must be space for any machine that is used to make it. Whether you make or buy the package for your lamps, there will have to be space and machines to fill them and seal them, Fig. 77-3. Machines that fill, close, and handle packages should be completely automatic if you are making large numbers of lamps. Since you are making much smaller numbers of lamps, some of these processes will be *manual* (done by men by hand).

Securing the Needed Industrial Materials

Your choice of packaging material is based on (1) how good it looks and (2) how well it contains, identifies, protects, and displays your product. There are many different materials that can be used to package products. Some of these are plastics, cellophane, paper and cardboard, glass,

metal and plastic tubes, and aerosol cans, Fig. 77-4. Your choice must be based on cost, product size, and how well the product must be protected.

You must think of how well your lamp must be protected from *impact* (jolts), *vibration* (shocks), *compressive stacking* (weight of packages stacked on top of each other), *humidity* (moisture in the air), light, and heat. To protect the lamp from jolts and shocks, cushioning materials can be used. These may be metal springs, natural materials like felts and wood-wool, or expanded plastics like foamed styrene and rubber.

The package itself must be strong enough not to break if many of them are stacked on top of each other. Usually, to keep the cost of the package as low as possible, you are willing to have a small number of packaged products damaged in shipping and handling them. Only very costly products or important military products need complete protection.

Your purchasing staff is in charge of getting the right materials as cheaply as they can. They must make sure that the right amounts get to the plant at the right time.

Making and Combining Components

Suppose the package is made from separate *components* (parts) like the corrugated board fillers in the desk lamp packages. These parts are made separately and *assembled* (combined) later, Fig. 77-5. Your production engineer may decide to buy one package part from someone else, rather than to make it in your plant. He would compare the cost to make it with the cost to buy it in order to make his decision.

Marketing

Advertising tells people about goods and services they can get. Those who make the product, those who ship it, and those who sell it all advertise. If your lamp firm were to grow into a large corporation that sold lamps all over America, it would probably advertise all over the country. Since it is a small firm you will probably advertise only in the places where you expect to sell lamps.

There are many *media* in which to advertise your lamp. There are newspapers, magazines, radio and television programs, billboards, posters in buses and trains, catalogs, direct mail ads, motion pictures that

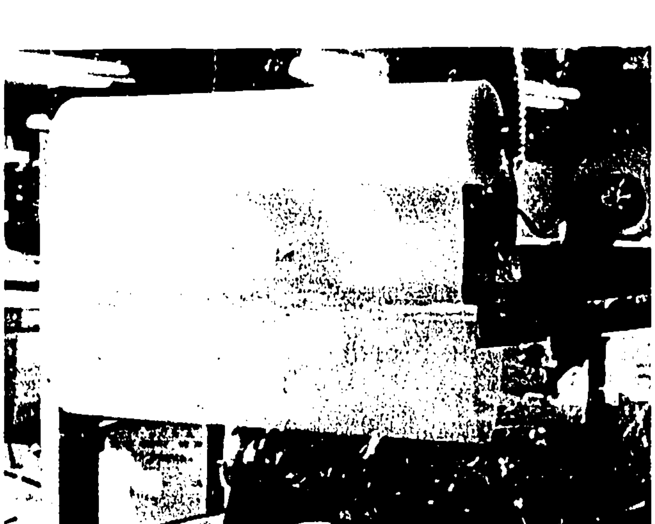


Fig. 77-4. You must choose the materials that will be used to make the package. This roll of plastic will be used to package desk lamps.

Fig. 77-5. The parts of this package can be assembled with the lamp it holds. This package is made up of the cardboard carton, cardboard baffles, plastic, paper, and labels.

can be shown to large groups of people, and exhibits at fairs and conventions, Fig. 77-6. Your *market research staff* (people who have special training in advertising) can help you choose the best way to reach the people who will buy your lamps.

Suppose your market research has shown that some of your desk lamp customers will be women who sew. You might buy an ad in a woman's magazine if it did not cost too much. Suppose your market research has shown that some of your customers will be hobbyists. You might buy an ad in a hobby magazine.

Many firms hire *advertising agencies* (firms who find the best ways to advertise products). The agency buys time and space in the best media for the product. Then it bills the firm for the cost of this time and space. The agency also gets a *commission* (percentage of the cost of advertising) for this service.

The agency staff also does market research, suggests ways to advertise, writes ads, and makes up ad layouts and illustrations. It is possible for a large corporation to hire its own advertising staff, but most small firms hire an agency to do some or all of their advertising for them.

Sales Promotion

Displays, pamphlets, technical brochures, and fact sheets are all "silent salesmen" for your lamps, Fig. 77-7. Other ways to *promote* (increase) sales include trade shows and exhibits at fairs, association meetings, and conventions. Companies usually ask their advertising agencies to work out the details of sales promotion at these large shows.

Personal Selling

Personal selling calls for direct contact between the seller and the buyer. Your sales manager must set up and *maintain* (keep up) ways to pick, train, and supervise his salesmen. He must come up with ways to pay them that not only reward them, but also make them want to sell more lamps. Most salesmen work on *commission* (percentage of what they sell). Thus their income depends on how much they sell.

Marketing Channels

Products move to market through many different *marketing channels*. A marketing channel is a way of getting a product to the

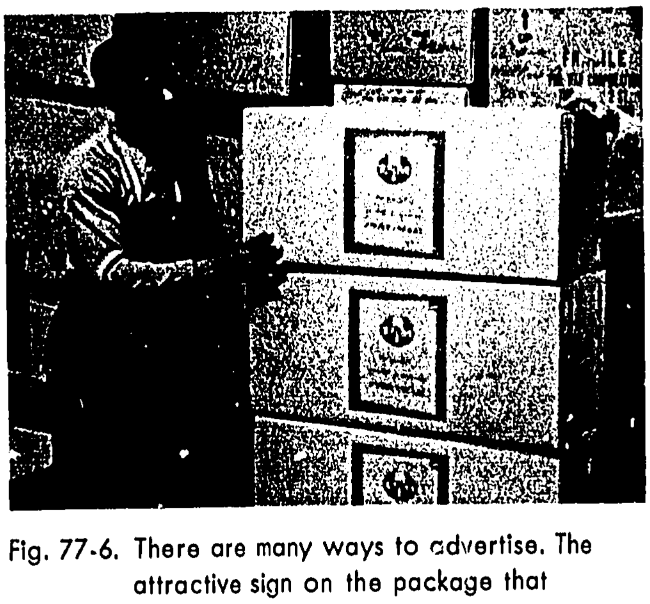


Fig. 77-6. There are many ways to advertise. The attractive sign on the package that identifies the product is one good way to advertise.

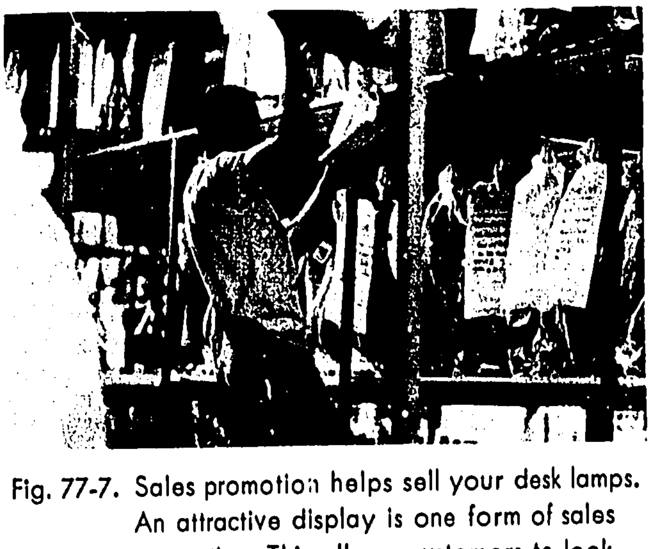


Fig. 77-7. Sales promotion helps sell your desk lamps. An attractive display is one form of sales promotion. This allows customers to look at and compare several styles of lamps at once.

customer. One of the most common channels is the *direct sale* and shipment of the product to the customer. Industrial products and certain others like milk, bread, and newspapers are sold widely this way.

Industrial products like pipe and building supplies are shipped directly to the customer. The *retailer* (someone who sells products directly to the public) often buys such bulky products like refrigerators in truckload or carload lots in order to lower the shipping costs. This type of sale and shipment is also cheapest for the manufacturer. It also makes the retailer want to buy in large volume lots.

Another marketing channel is made up of a *wholesaler*, a retailer, and finally the customer. This is the most common channel when the manufacturer can ship products cheaply in large carload and truckload lots to the warehouses of wholesalers near his major markets. The *wholesalers* buy the products directly from the manufacturer and keep stocks of them on hand to sell in smaller numbers to retailers in that market area. The wholesalers do not usually sell products directly to the "man on the street," but sell them only to the retailers. It is the retailers who then resell them to the customer, the "man on the street," Fig. 77-8.

Pricing

One of the most important things a customer will look for on your desk lamps is its *selling price* (how much a lamp costs to buy), Fig. 77-9. Your lamp must be priced to compete with others like it on the market. The selling price is likely to be the highest price at which you can sell your lamps rather quickly and still make a good profit on them. You should set up a selling price that will make both wholesalers and retailers want to sell them.

The federal government has set up a great deal of control over selling prices. Your company must be careful not to *violate* (disobey) *restraint-of-trade* and *antitrust laws* (laws that say that you and other lamp companies may not get together and "fix prices"). In your advertisements and sales promoting techniques, your company must not make false or misleading claims about your lamps, or you will be brought into court by some federal agency.

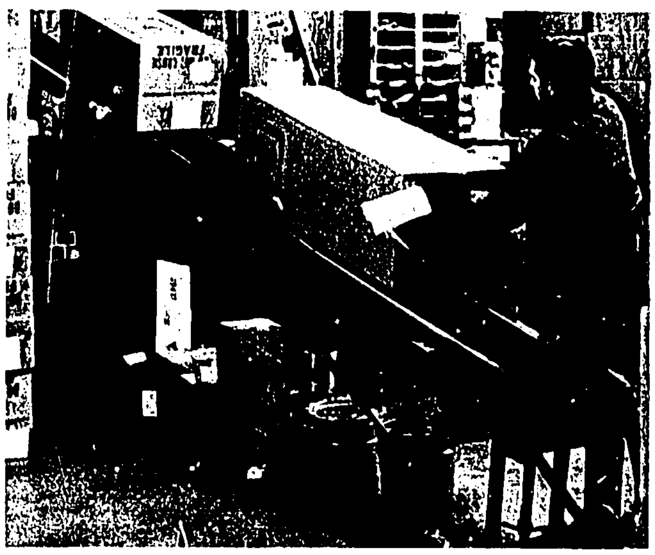


Fig. 77-8. These lamps have been sent to a retail store where they will be sold to the public. This way of getting the lamp from your plant to your customer is called a *marketing channel*.

Fig. 77-9. If several styles of lamps are being made, they must be marked in some way when they are put in a package. Such markings should show both the style of the lamp and its selling price.

Summary

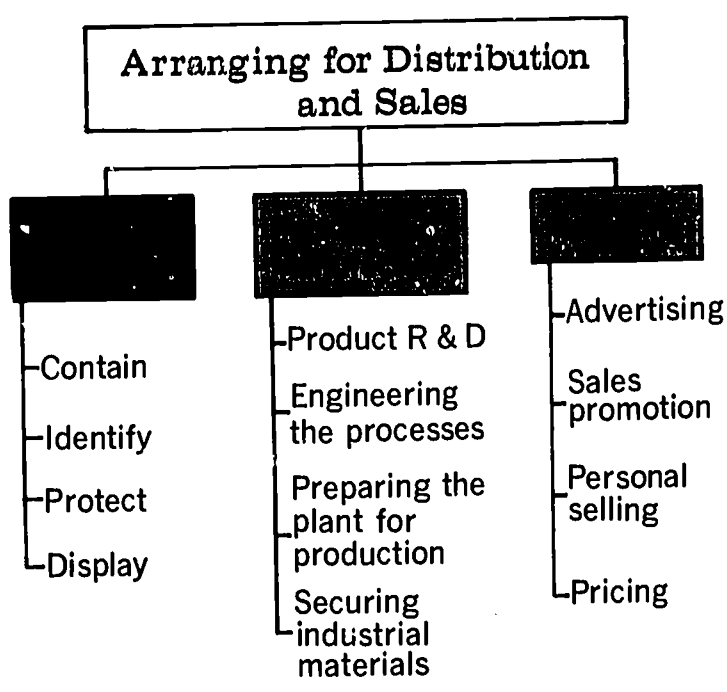
A manufacturer must make or buy a package that will protect his product and attract customers to buy it. There are a great many different kinds of packages and packaging materials. Packages must be designed and made in the same careful ways that the product itself was.

People learn about a product through advertising. A manufacturer, a wholesaler, or a retailer may advertise a product. Special skills are needed to pick the best ways to reach customers and to write the ads that will attract them.

Sales promotion materials also advertise the product. Salesmen, working under a sales manager, sell products directly to the customer, the "man on the street."

There are several other marketing channels to get the product to the customer. Wholesalers buy products in large volume lots. In turn, they sell them to retailers in smaller lots. Retailers in turn sell them to the public in even smaller lots, often in single units.

The selling price of a product affects its sales. The product must be priced high enough to make a profit, but low enough to compete with other products like it on the market.



Terms to Know

consumers
advertise
market
distribute
planned
organized
controlled
regulations
contain
identify
protect
display
performance
appearance
maximum cost
manual
impact
vibration
compressive stacking
humidity
components
assembled
media
market research staff
advertising agencies
commission
sales promotion
promote
personal selling
maintain
marketing channels
direct sale
retailer
wholesaler
selling price
violate
restraint-of-trade laws
antitrust laws

Think About It!

1. Look at a package and describe how it contains, identifies, protects, and displays the product.
2. You have developed a desk lamp which you want to sell to teenagers. List as many places as you can think of where you would advertise to reach as many teenagers as possible.

READING 78

Liquidating the Corporation

In the last ten readings, you have learned how to form and run a corporation. You have gone through all the steps you must take to plan, organize, produce, control, and sell a product in order to earn a profit. Think back over what you have done in your lamp company in the past few weeks. Ask yourself some questions about this corporation that you formed and ran. How *efficient* was it (how well did it produce lamps)? How can this efficiency be measured? How could it have been *improved* (made better)?

In this reading, you will find answers to these questions. You will also learn how a corporation is *dissolved* (ended). Also, you will find some *predictions* (guesses) about corporations in the future.

Dissolving the Corporation

Each year, about 400,000 corporations *dissolve* (go out of business). A corporation goes out of business by a legal process called *dissolution*, Fig. 78-1. This means that the corporation gives up its charter and sells its *assets* (land, buildings, tools, machines, and furniture). All of the *debts* (bills) must then be paid out of the money from the sale of the assets. Only then can the stockholders get any money from their *investment* (money put into the corporation to help it get started or to keep it in business). If there is any money left after the debts have been paid, it will be divided among the stockholders.

Most of the corporations that are dissolved are small and have been in business for less than five years. There are several reasons why small businesses are dissolved. One reason is that a firm may make too many products and not be able to sell them. If money doesn't come in from sales, then the firm can't pay its bills for materials used to make the products, Fig. 78-2.

The steps you take to dissolve a corporation differ from state to state. In some states, the corporation has to sell its assets and pay its debts before its charter can be *revoked* (given up). In other states, the charter has to be revoked before the assets can be sold. You may choose to go out of business (*voluntary dissolution*), or you may be forced to go out of business (*involuntary dissolution*).

Voluntary Dissolution

If you choose to go out of business, your stockholders must agree that your corpora-

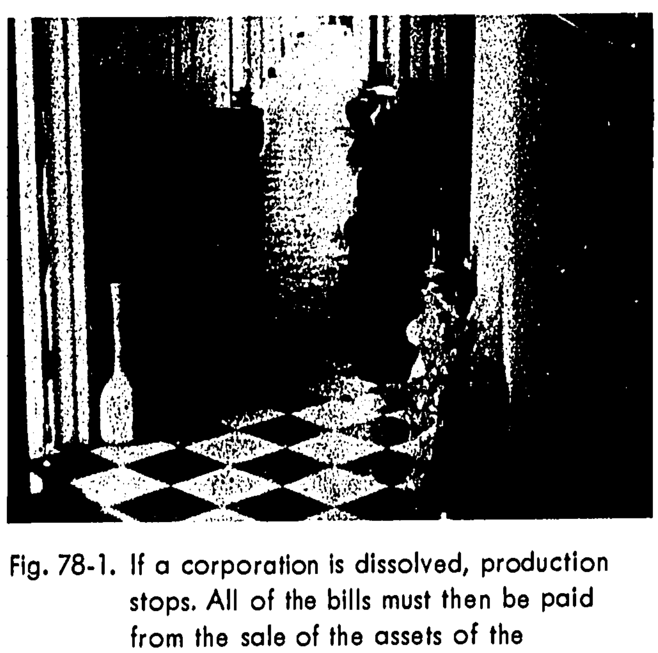


Fig. 78-1. If a corporation is dissolved, production stops. All of the bills must then be paid from the sale of the assets of the corporation. Only then can the stockholders get any money from their investment.

tion will give up its charter. The board of directors will call a meeting of the stockholders, and a majority of them must vote to dissolve the corporation.

Sometimes stockholders themselves want to dissolve the corporation because they don't like the way the board of directors is running it. In this case, the board of directors might refuse to call a meeting of the stockholders. Then the stockholders themselves must either call the meeting or sue the directors to force them to call it. At this meeting, the stockholders could vote to give up the corporation's charter. Thus the result would be the same as if the directors had called the meeting.

Why does a corporation choose to go out of business? The most important reason is *business failure* (when there is not enough income from sales to pay the bills for materials already used). When this happens, the board of directors or the stockholders no longer feel sure that the corporation can earn any more profits.

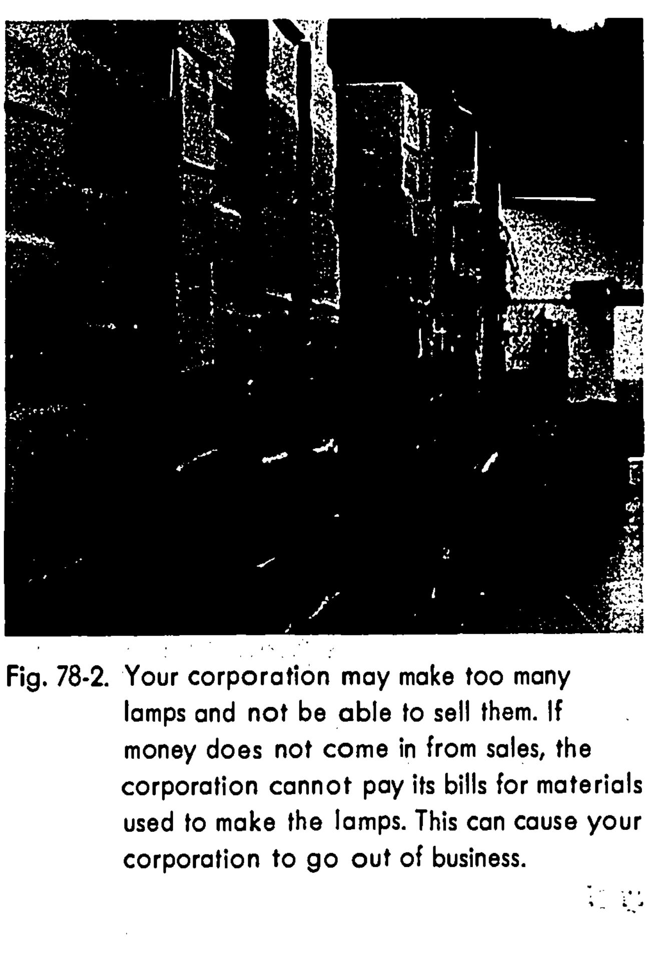


Fig. 78-2. Your corporation may make too many lamps and not be able to sell them. If money does not come in from sales, the corporation cannot pay its bills for materials used to make the lamps. This can cause your corporation to go out of business.

Involuntary Dissolution

In most states, corporations can be dissolved by people outside the corporation. There are four ways that corporations can be forced to go out of business.

1. *Bankruptcy.* The courts can dissolve a corporation if it is not able to pay its debts.
2. *Failure to meet state regulations.* In some states, an agency of the state can revoke a corporation's charter if the corporation does any illegal business, fails to pay its taxes, or fails to file any reports that state laws say it must file.
3. *Improper purposes.* The courts can dissolve a corporation if it is set up for any purpose that is illegal in the state or community in which the corporation is set up.
4. *Lack of activity.* Some states can dissolve a corporation if it fails to carry out the purposes stated in its charter.

The Results of Dissolution

When a corporation is dissolved, it loses its status as an *entity* ("artificial person"). This means that it can no longer sue or be sued in court. It cannot make contracts, buy or sell property, borrow money, or carry out any of the purposes stated in its charter.

The corporation must then sell its assets and pay all its debts. If there is any money left after the debts have been paid, it is divided among the stockholders according to the number of shares of stock they each hold. Suppose, though, that there is not enough money from the sale of the assets to pay all the corporation's *creditors* (people or companies it owes money to). In this case, if all its creditors agree, the corporation can pay its debts with them through private *settlements* (agreements). A *trustee* is chosen by the creditors to decide how the debts will be paid. Often the trustee tries to make sure that each creditor gets a fair share of the money owed him.

The *financial* (money) matters of a large corporation are very *complex* (complicated). Thus disagreements over fair settlement of debts are quite common. In this case, a court chooses a *receiver*. The receiver sells the assets, pays the debts, and divides whatever is left among the stockholders.

Once the corporation's assets have been sold and its charter revoked, the corporation no longer exists. It cannot sue, or be sued by anyone for anything it has done in the past. It cannot be forced to pay any more debts after the court has approved whatever way has been set up to settle its debts.

Corporation Efficiency

The success of your corporation depends on how well it is run, Fig. 78-3. To make a product and sell it at a profit, you cannot have high manufacturing costs. If these costs are high, your profits will be low and you will soon be out of business.

Well-trained people are needed to run a corporation well. Poorly trained workers waste time learning how to do their jobs right. Often they raise costs even more by making *defective* (poorly made) parts that have to be thrown out.

To run a corporation well, you need good management, Fig. 78-4. The managers of your corporation must be able to make plans, set up their machines and workers, and check to see that the plant is running smoothly and that every person is doing his job in the best possible way.

Good managers can improve the corporation by putting into practice any new and different process that will make it run better, Fig. 78-5. This means that the good manager must be aware of new inventions or developments. He must know about new materials, designs, machines, and techniques that would help the corporation make its product more cheaply or with better quality, Fig. 78-6.

Fig. 78-3. The success of a corporation depends on how well it is run. Every job must be studied to find out the best possible way to do it. For instance, suppose this stock clerk moved only one carton at a time instead of five. Would this be the best way to move the cartons?

Fig. 78-4. To run your corporation well, you need good management. Managers must always find out where improvements can be made. This means constant study and much thought by everyone on the management staff.

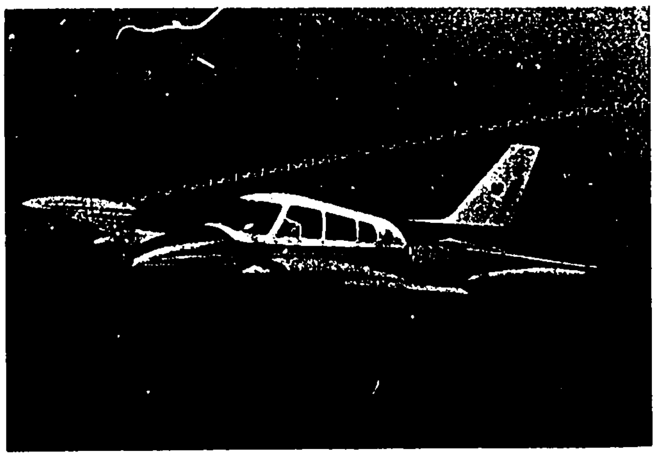


Fig. 78-5. Today, speed in getting things done is one way to do them well. It is common for corporation managers to do business on the way to another business appointment. The future may make even greater demands on top management staff.

Corporation Effectiveness

If the corporation is well run, it will keep on earning a good profit over a long period of time. It will also *maintain* (keep up) or improve its sales record. This means that your corporation should increase its sale of lamps each year by at least the same percentage that the total sales of all lamps goes up, Fig. 78-7.

If a corporation is well run, its managers, directors, and stockholders feel sure that it will continue to make and sell useful products and to earn a profit. The public that buys its products and other companies that make the same kind of products also expect it to stay in business.

Customers form their opinions of how well a corporation is run on the basis of its products. High-quality products are a good sign of a well-run business. Low-quality products are a good sign that the corporation is quite likely to go out of business soon.

The well-run corporation is interested in living conditions as well as profits. It wants to make and sell products that will make the lives of its customers better. It tries to become active in programs that will make living conditions better for everyone. As an

Fig. 78-6. A well-run corporation must be able to store and get data back quickly. Computers are often used to do this today. The two disks shown here have millions of bits of data on them.

Fig. 78-7. One way to measure how well your corporation is being run is to see how fast it sells the lamps it makes. This means that you should make them as fast as you sell them to customers.

employer, it tries to make working conditions better for its workers, to get rid of unfair personnel practices, and to improve the social and personal welfare of all its workers.

Corporations and the Future

The corporation will probably be the most common and widespread way to do business in the future. Only the corporation is able to raise the large amounts of money that are needed to buy the complex and costly machines used in modern production.

There is always room for new corporations. Because technology can change so fast today, it is possible for someone who has a new idea to develop it and form a corporation to make and sell products based on that idea.

Today's large corporations will probably exist for a long time in the future. Large corporations can do research to keep up-to-date on new developments. Some of the most important research is now being done by these corporations. New knowledge can be quickly used to design new products.

Corporations today want to make living conditions better than they ever were before. They know that business cannot get better if their customers do not have jobs and good places to live. It is likely that corporations will continue to improve living conditions in the future.

In the next fifty years, more and more people will work for corporations, Fig. 78-8. Corporations will have to come up with challenging and interesting jobs for them.

For the last ten years, there has been a trend for corporations to *merge* (join) with other corporations that make entirely different products. These are called *conglomerates*. Some people say that a conglomerate can make each product better because it makes them both. While others doubt whether this is true, only the future holds the answer.

Some people are critical of large corporations, but others say that corporations have greatly helped this country's economic growth. Because of their large size, corporations have been able to make better and cheaper products, and customers have enjoyed lower prices, better-quality products, and improved living conditions.

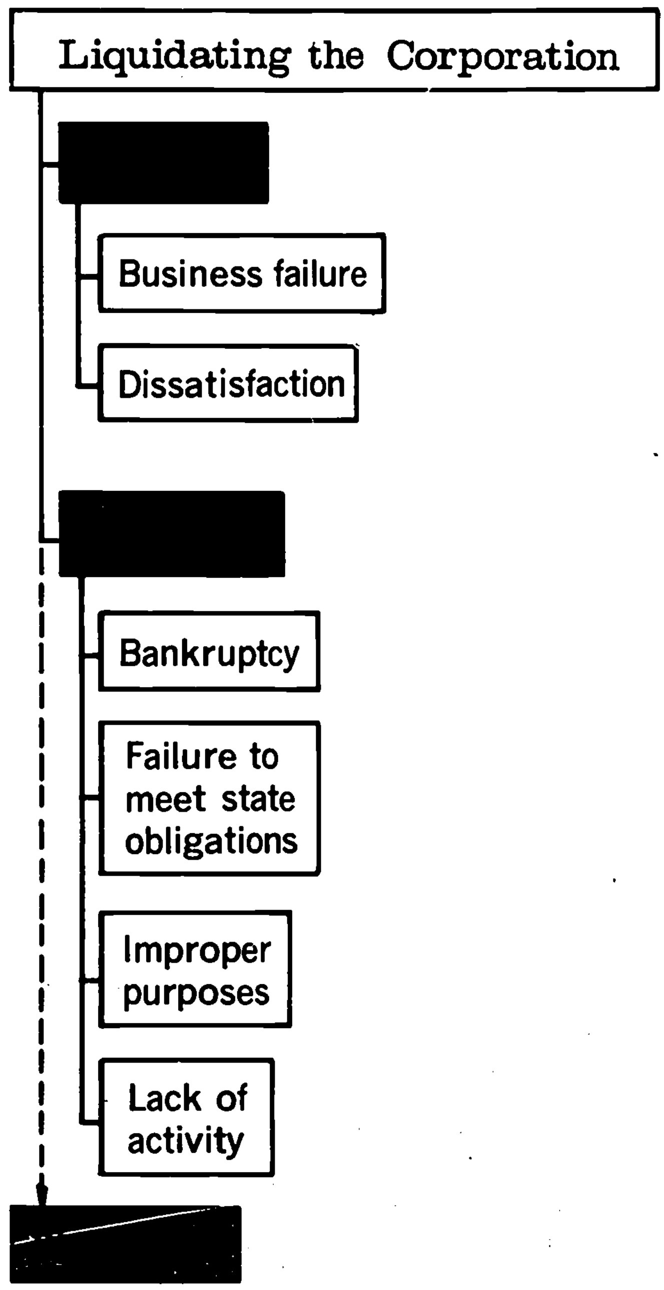
Fig. 78-8. There will be many changes in corporations in the future, but a few jobs will not change very much. For instance, this worker is putting gold leaf on the lamp base in much the same way as it was done centuries ago.

Summary

In these last ten readings, you have learned how a corporation is formed, how it is run, and how it is dissolved. You have followed all its stages by forming and running your own corporation to make and sell desk lamps. You have learned how a product like a desk lamp is made and sold. You have learned how and why some corporations go out of business. The corporation is not the only way to do business, but it is such an important way that everyone should have a basic knowledge of how and why it works.

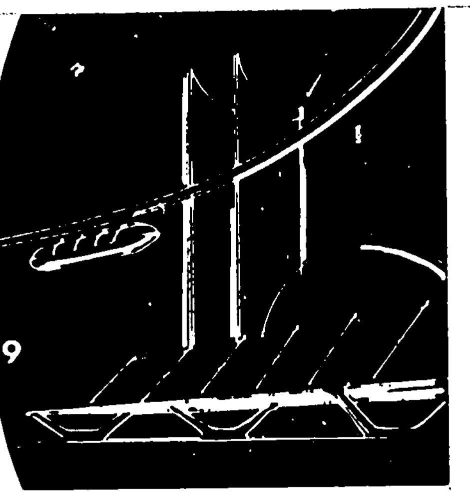
Terms to Know

efficient
improved
dissolved
predictions
dissolve
dissolution
assets
debts
investment
revoked
voluntary dissolution
involuntary dissolution
business failure
bankruptcy
failure to meet state regulations (rules)
improper purposes
lack of activity
entity
creditors
settlements
trustee
financial
complex
receiver
defective
maintain
merge
conglomerates



Think About It!

1. Corporations go out of business (*dissolve*) for many reasons. Look in the local newspaper for corporations in your community that are going out of business. Why are they going out of business?
2. Corporations today are more interested in making living conditions better than they ever were before. How are corporations in your community helping to fight air and water pollution?



READING 79

Manufacturing in the Future

Manufacturing in the future will be faster. It will be more *complex* (complicated). It will be more *automated* (machines run by other machines). It will be more *efficient* (well run), and better able to make products at much less cost. To run the plants that will make these complex products, we will need managers and production people who are well educated and very skilled. Some of the largest technological developments give us a hint of what manufacturing will be like if it is to make the products we will want and need in the future.

The Past

A hundred years ago, almost anyone knew how to make the products that were used then, Fig. 79-1. A village forge was seen almost everywhere in the country. Next to it was a mill to grind grain, a cobbler shop to make and fix shoes, and several other simple manufacturing shops. These were all open to public view. Most people knew how they were set up and run. The streets were still lit by gaslights. People still rode on horseback and in carriages.

Fifty years ago, people were starting to use such new forms of energy as electricity. They were also starting to use such new and more complex machines as radios and airplanes. Those who ran manufacturing plants were learning new techniques of management. For instance, they learned to divide big jobs into smaller parts so that one person could learn how to do his own job in a short time. The need for workers with complex skills was *reduced* (cut down), and men became more like parts of the production machines they ran.

In the past, man has had little control over or concern for his environment. He manufactured goods which became part of the environment. Little concern was given to how the goods he produced affected the environment. When products wore out or were replaced by newer products, the old products were scrapped. They were burned, buried, or dumped into the waters. Because of the seemingly small amount of material and pollution, compared to the whole earth, no effect on the environment was seen. No effect was seen because the build-up of waste and pollution happened very slowly.

The Present

In recent years, complex products have been made by complex machines and proc-

Fig. 79-1. This is manufacturing of the past. We have come a long way since these crude tools were used to make industrial goods.

esses. Large manufacturing plants grew up on a single *site* (location). In these plants, raw materials were completely changed into finished goods.

During the past ten years, these large plants have been replaced by plants in which standard stock, single parts, or assemblies are made. We usually think that the U. S. makes huge numbers of *identical* (exactly alike) products, parts, and models. The average run, though, of most manufactured parts is only about fifty per day.

Today, fewer workers are being used as parts of the machines they run. Many workers are now being used to run such complex and costly machines as *numerically-controlled machines*. Fewer skilled machinists are needed, because these machines can make parts without mistakes. They can also make parts to very close *tolerances* (how much a part can differ in size and shape and still fit with its matching parts). All a man does now is to thread a tape into a machine much as he would thread a tape into a home tape recorder. The *data* (information) needs to be put on the tape only once, Fig. 79-2. It is usually done by a trained engineer.

The rapid change in management in recent years can be shown by looking at some of the new techniques that are used to make new products, Fig. 79-3. In the past, you could shut down the production line, bring in new machines and tools, and put workers back at their old jobs. Tomorrow, you may even have to build a new plant because the new machines and tools will not work like the old ones at all. The workers in your old plant often won't be able to run the new machines or learn the new techniques. This means that there will need to be new and different kinds of schooling and training in the future.

Today, men are beginning to recognize the problems that result from making the man-made environment. Manufacturers and consumers are becoming more aware of the part they play in controlling the environment, in controlling waste, and in stopping pollution. Manufacturers are researching and developing the technologies that will help us live in a better world.

The Future

The way we live will be changed by manufacturing in the future. We will be better

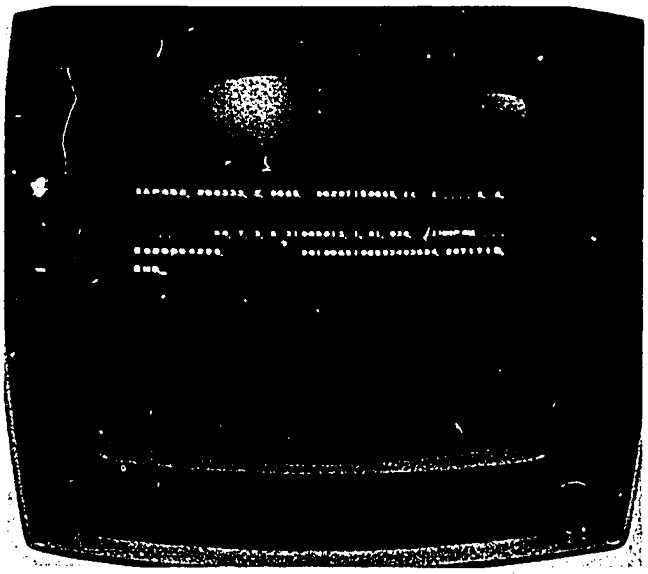


Fig. 79-2. This is manufacturing of the present. A video device shows the complete history of a motor vehicle in computer language.

Fig. 79-3. Today's top management staff, scientists, and engineers are making plans for the future in manufacturing.

educated. We will get better medical care. See Fig. 79-4. Even our ways of traveling around and shipping goods will be different. See Figs. 79-5 and 79-6.

One of the biggest concerns in the U. S. in the future is likely to be education. We are now starting to find out how it is that a person learns something new. We are also finding out how we can teach him and give him the data he needs to know in order to learn something new. There are simple teaching machines we can use now. Even more complex ones are being designed by research teams. The work of teachers has been carefully studied. From this, we have found that much of the work that they do now can be done through motion pictures, filmstrips, and TV films. We are starting to find out ways to measure how creative and imaginative a child is. We are also starting to find out how to improve this talent. We are finding out that it is more important to help a child learn *how to learn something new* than it is for him to learn *what has already happened*. In the future, we are likely to find ways to develop this skill through machines and new techniques. In this way, people will be able to deal with the new and complex problems they will have to solve.

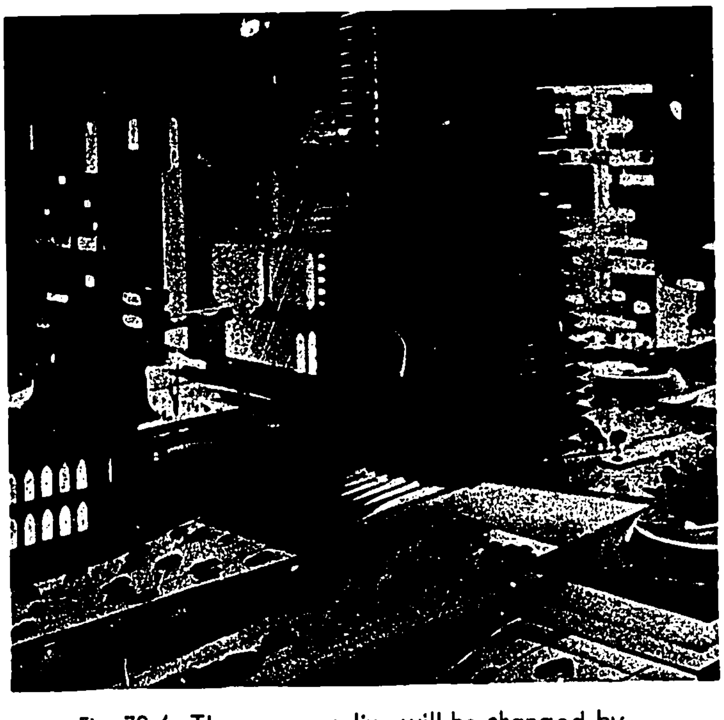


Fig. 79-4. The way we live will be changed by manufacturing in the future. We will be better educated and will also get better medical care.

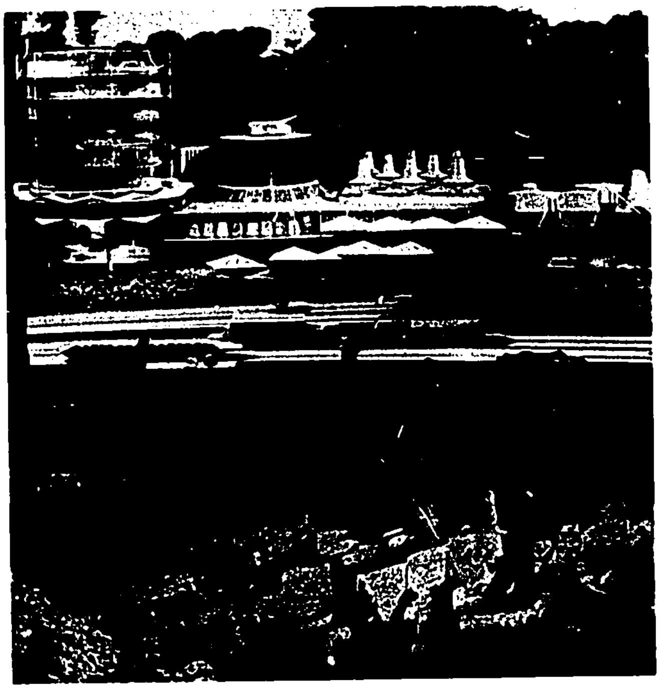


Fig. 79-5. The past and the future are seen in this fanciful sketch of a futuristic highway that may link nations together.

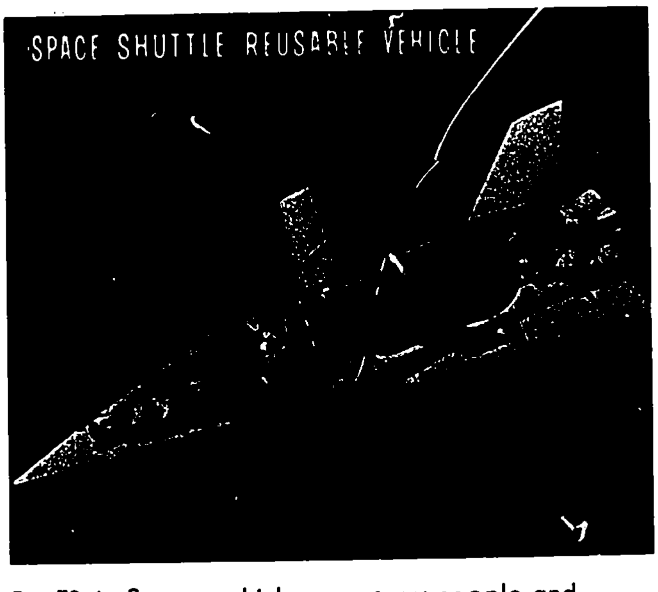


Fig. 79-6. Space vehicles may carry people and supplies to and from stations in outer space.

Another important new field that will be open to manufacturers in the future is *medical care*. We are likely to see machines that can *diagnose* (find out the cause of) ailments of the human body. Most of these will also be able to *prescribe* (suggest) ways to cure these ailments. There will also be machines to help the patient get well. They will observe and record whenever his behavior is different from what it should be. Perhaps such machines will be made in such large numbers that they will be used in the home as well as in the hospital.

One of the last physical frontiers to explore in the world is the ocean, Fig. 79-7. Many machines need to be designed in order to develop, or start to develop, the ocean as a source of food, minerals, and energy, or even as a place for us to live. Manufacturing may even be done in outer space. There we can make and assemble parts where it is completely free of dust and dirt, Fig. 79-8.

Conservation (saving and using carefully) of our natural resources is likely to be an even greater concern to manufacturers in the future, Fig. 79-9. On the one hand, nat-

Fig. 79-8. When outer space is finally explored, manufacturing can be done in the dirt-free space capsules seen here.

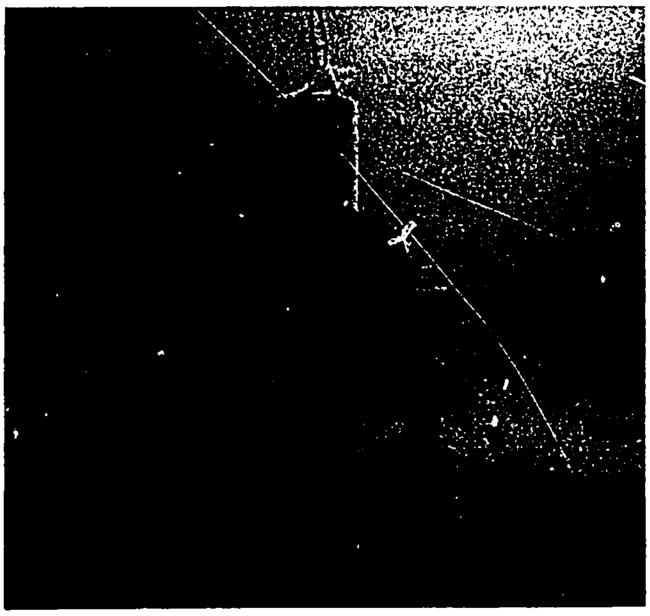


Fig. 79-7. One of the last physical frontiers to explore is the ocean. We will need the resources of the sea in order to make progress in manufacturing.

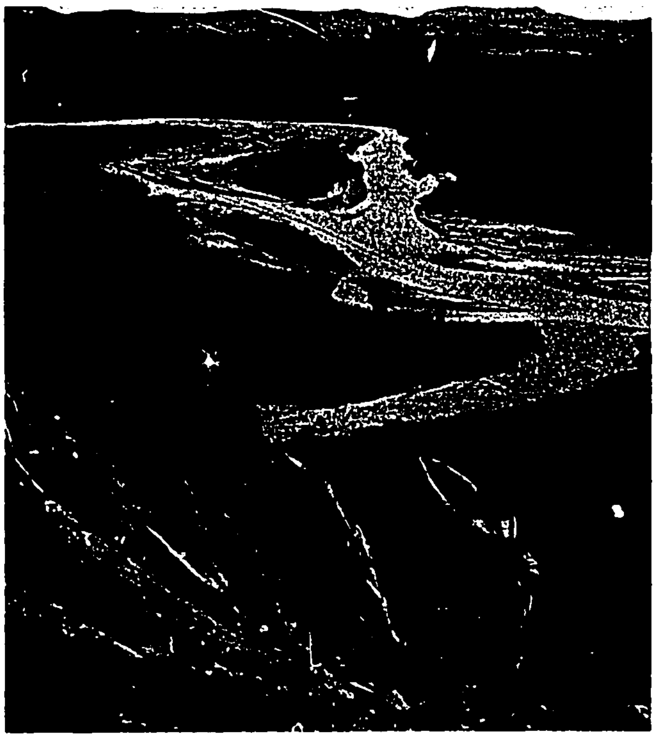


Fig. 79-9. We must be concerned with the conservation of our natural resources. Deposits of minerals, coal, oil, and other natural resources will not last forever.

ural resources can be saved if we use more materials over again, instead of throwing them away. On the other hand, our resources can be saved if we cut down the amount of harmful waste that is returned to the air, water, and land around us. For instance, our wastes can be *purified* (cleaned) to the point where they do not *pollute* (poison) the air, water, and land they are returned to. In the far distant future, there may be self-contained communities where most of the products we use can be saved and made or built over again without adding any more materials or resources to do so.

It is now common to use two or more fields of technology to solve new problems. For instance, biology and mechanics have been used to develop mechanical hearts that will make today's heart transplants seem very old-fashioned. Photography, chemistry, and mechanics have been used to make machine parts that can make gears small enough to be used in watches and at a cost of a fraction of a cent each. Photography, chemistry, and electricity have been used to build on a one-inch square piece of ceramic tile a computer that used to need 5,000 tubes to run. These ways of joining different fields of technology to develop new products, machines, and techniques can only be understood by people who study more than one of these fields.

In the past, it took from two to twenty years to develop new products. With some products, it took even longer. In the first twenty years after the first airplane had been built, most people did not think there was any use for it. Now, of course, planes can move large numbers of people and goods in very short times over very great distances.

People have accepted computers much more quickly. Computers have been used to do many different kinds of jobs. Their costs have been slowly reduced. It has been said that by 1980 almost every machine in almost every plant will be run by computers, Fig. 79-10. In the next few years, large computers that run many machines will still be needed, since computer costs are still quite high. But ten years from now, the cost of computers will be so low that every machine may be run by a computer.

Summary

Manufacturing used to be simple in the ways it was set up and run. Each worker often needed many different skills. Modern manufacturing uses such different and complex machines and techniques that most workers need very few skills.

In the future, manufacturing will use computers to run many of the machines that are now run by men. Workers will need more complex schooling and training so that they in turn may make, run, and service automated machines.

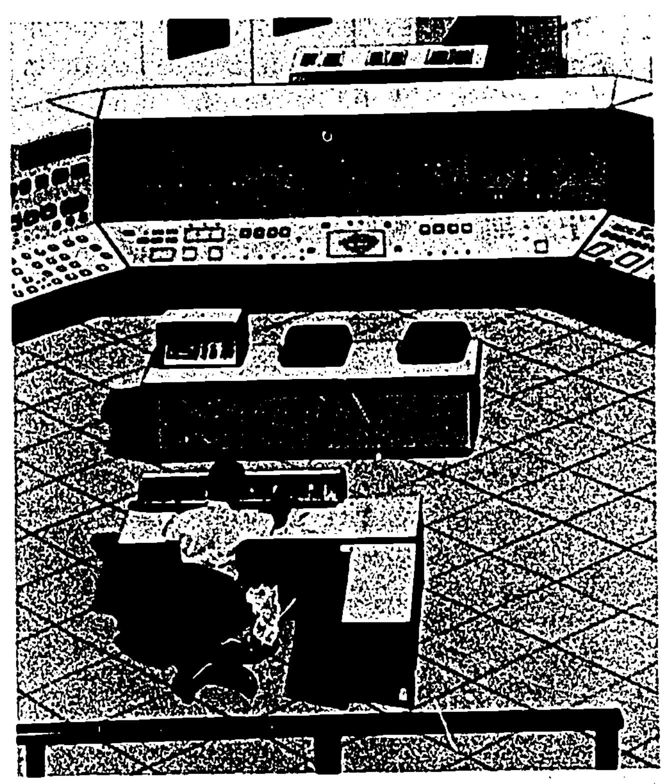


Fig. 79-10. Computer-controlled machines are becoming more and more of a reality. In the future, perhaps, one man will be able to control and produce goods that take 1,000 men to make today.

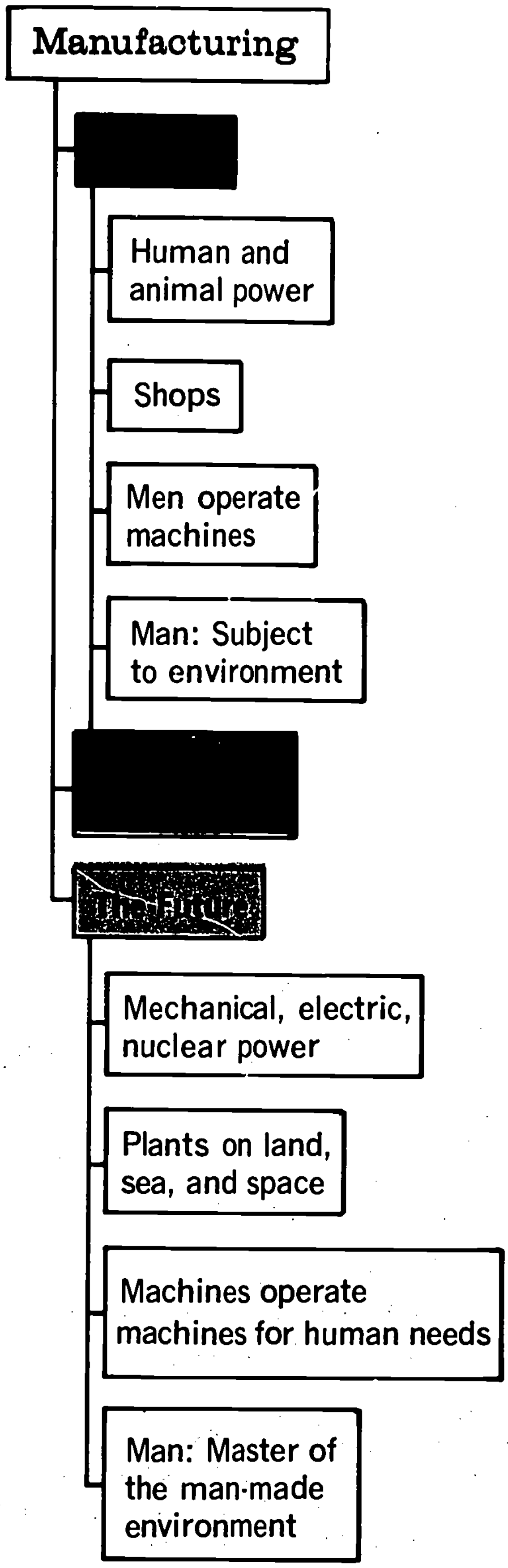
There will be many more people living in the world of tomorrow. There will be fewer, though, who understand it. Those who do understand it and know how to make what the people of the future will want and need are likely to be in great demand. They are likely to be among the leaders of tomorrow.

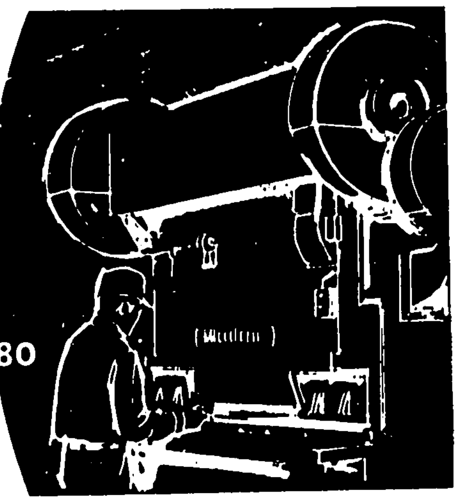
Terms to Know

complex	data
automated	educated
efficient	medical care
reduced	diagnose
site	prescribe
identical	conservation
numerically-controlled machines	purified
	pollute
tolerances	pollution

Think About It!

1. How will manufacturers of the future use over again materials that are considered waste? How will using them over again affect the *pollution* problems we are facing now?
2. What jobs that now exist in your community do you see changing as a result of technological progress in your community?





Story of Basic Machine Tools

In these next three readings, you will learn about some of our larger manufacturing industries. These industries use the standard stock materials made by *primary manufacturers* (those who process raw materials into standard stock materials). The standard stock is processed to make *components* (parts) and to *assemble* (combine) these into finished products. The finished goods are then sold and shipped to customers.

The machine tool industry is one of our most important ones. Machine tools are used to make all the machines that are used in construction and in manufacturing. In this reading, you will learn about machine tools and the machine tool industry.

The Machine Tool Industry

The story of machine tools is the story of man's progress. From frozen apple pies, permanent-press pants, and wristwatches, to orbiting satellites, space capsules, and lunar modules, all products today are made directly or indirectly by machine tools. They were either made by machine tools or made by machines that were made by machine tools, Figs. 80-1 and 80-2. You can see that we would not be able to feed and clothe ourselves without machine tools. We would not enjoy our present way of living without machine tools.

Machine tools have helped us to build a large manufacturing system. They have helped us to make large numbers of products at lower costs. Because of these lower prices, people have wanted more products. Because people have wanted more products, manufacturers have made more products.

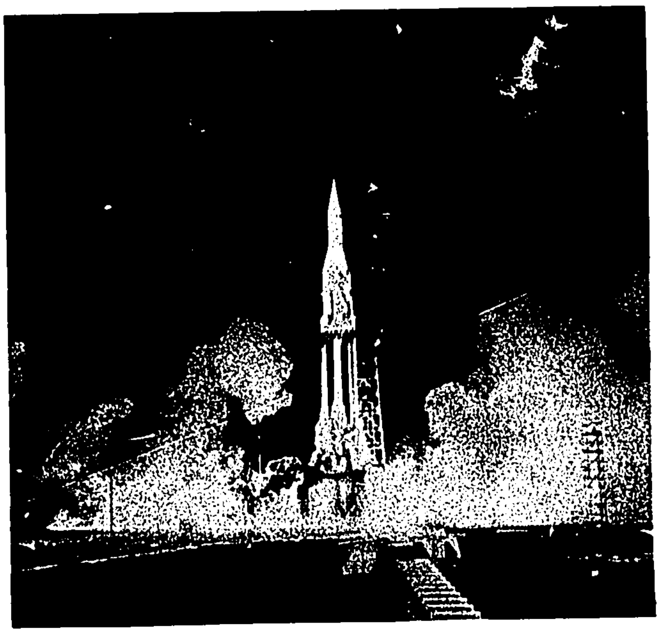


Fig. 80-1. A rocket lifting off the launch pad at Cape Kennedy is a product of modern machine tools. The millions of parts of a huge rocket could not be made without machine tools.

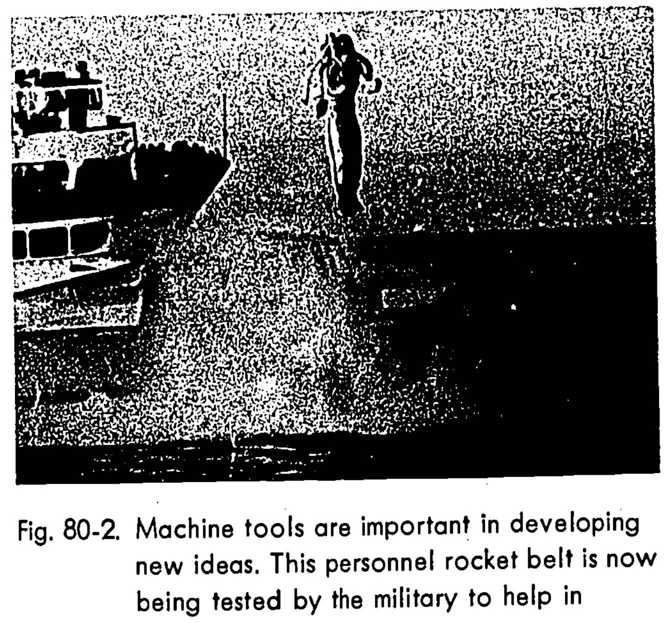


Fig. 80-2. Machine tools are important in developing new ideas. This personnel rocket belt is now being tested by the military to help in amphibious landings.

Because more products have been made, more people have been hired to help make them. Thus increased production has meant more jobs. More jobs mean more income and a higher standard of living. More income means more products can be bought. As you can see, this system can keep going as long as people want and can buy the increased number of products that are made.

The Machine Tool

The National Machine Tool Builders' Association defines a *machine tool* as a power-driven machine, not *portable* (carried by hand), used to shape or form metal by cutting, by *impact* (striking), by *pressure* (force), by electrical techniques, or by some combination of these techniques. In this reading, you will learn about two major kinds of machine tools. They are (1) *basic machine tools* and (2) *special machine tools.*

Basic Machine Tools

Basic machine tools make special machine tools. These are the real machine tool builders. The basic machine tools use one or more of five techniques to make special machine tools. These techniques are (1) *drilling* or *boring,* (2) *turning,* (3) *milling,* (4) *grinding,* and (5) *planing* or *shaping.*

Drilling

Drilling is the technique of cutting a round hole in metal by using a *rotating* (turning) drill. *Boring* is the technique of finishing a hole that has been cast in the part or that has already been drilled. If an already drilled hole is finished to a close *tolerance* (how much a part may differ in size and shape and still fit with its matching parts), this is called *reaming.* If threads are cut inside an already drilled hole, this is called *tapping.* All these techniques are usually done with drilling tools and machines, Fig. 80-3. They can also be done on many different kinds of other basic machine tools and special machine tools.

Turning

Turning is a technique that rotates a piece of metal against a cutting tool. Turning is a lot like peeling an apple with a knife. The lathe is the basic machine tool that is used for turning, Fig. 80-4.

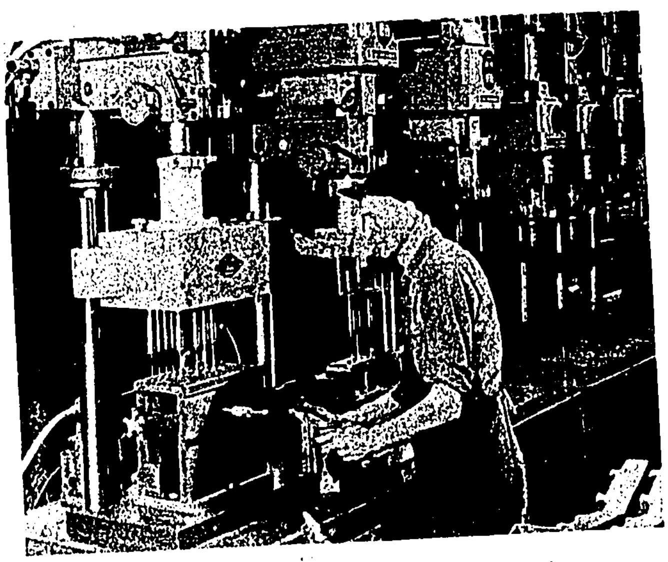


Fig. 80-3. Drilling machines come in many different sizes. This drill has multiple spindles.

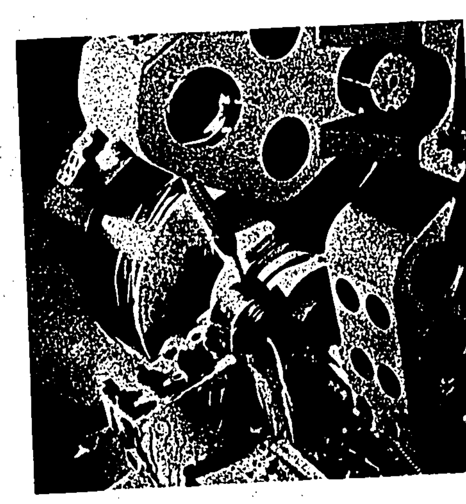


Fig. 80-4. This lathe is turning down a piece of metal. The white liquid is cooling the cutting tool so it will work at its best.

Milling

Milling is a technique that rotates a round cutter with several cutting edges to shape metal parts, Fig. 80-5. Milling metal is a lot like cutting wood with a hand saw. The only difference is that the cutter is moving all the time. Both techniques make chips. If teeth are cut into gear wheels, this is called *hobbing*, Fig. 80-6.

Grinding

Grinding is a technique that shapes a piece of metal by holding it against a turning *abrasive* (rough) wheel, Fig. 80-7. Grinding is also called *abrading*, or *abrasive machining*. If an already drilled hole is made larger by a turning abrasive wheel, this is called *honing*. If the surface of a metal part is smoothed and polished to a very fine finish, this is called *lapping*.

Planing and Shaping

Planing and shaping metal is a lot like planing wood with a carpenter's hand plane. A planer has a fixed cutting tool, and the metal is moved back and forth under it. In shaping, the metal is held still, and the tool moves. If a narrow *groove* (slot) is cut into the metal by a special planing and shaping machine, this is called *slotting*, Fig. 80-8. Planers are usually large machines that are able to smooth or shape metal surfaces 15 to 20 feet wide and 30 to 40 feet long.

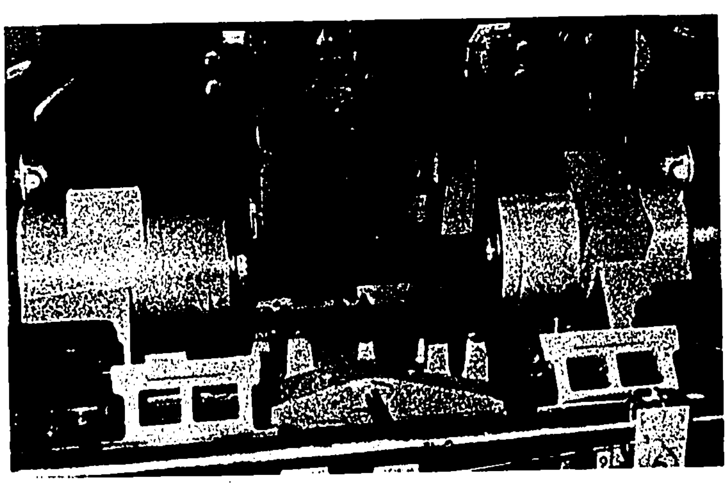


Fig. 80-5. This milling machine cuts down both ends of an engine block at the same time. The engine block is pinned, clamped, and wedged to hold it against the cutter edges.

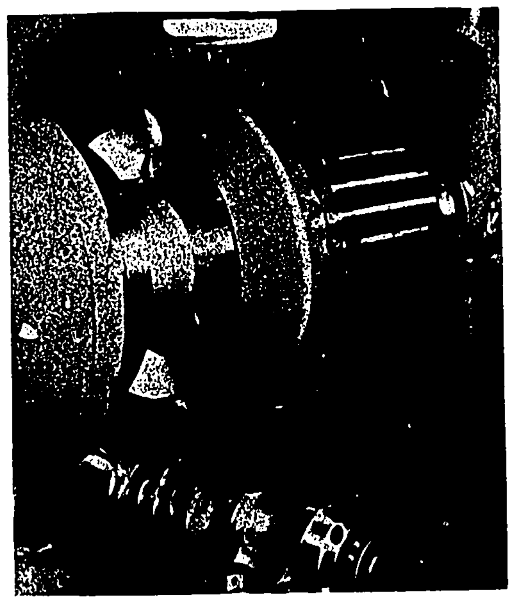


Fig. 80-6. A special machine tool may be a gear-hobbing machine. This machine hobs two tractor gears at the same time.

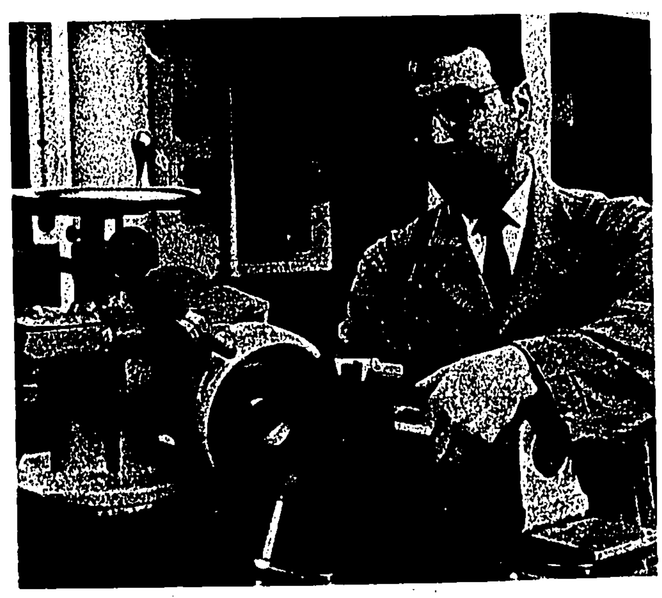


Fig. 80-7. A dry-carbide grinding technique with a diamond wheel is used on this tool and cutter grinder to sharpen this mill cutter.

Special Machine Tools

Special machine tools are the ones that have been made to *extend* (add to) the work done by the basic machine tools. They often do what man used to do by hand. One set of these special machine tools does the work the blacksmith used to do. These include the mechanical and hydraulic press, the press brake, the shear, the drop hammer, the forging machine, and the punch press, Fig. 80-9.

There are also special machine tools that are used to make gears (Fig. 80-6), assembly machines, inspection machines, and many other new machines and machine tools. Special new machines are being developed every day that require special machine tools to make them.

The Scope of the Machine Tool Industry

The machine tool industry is quite small when you compare it to the giant industries that use its products. There are not more than 75,000 people working in the machine tool industry. Shops with 5,000 workers are as rare as those with 20 or less. The average number of workers in a machine tool manufacturing plant is between 200 and 250.

The biggest product of the machine tool industry is its engineering skills and knowledge. After all, engineers are the ones who build the machine tools that lower costs, solve problems, and help to make better products.

More than 90 percent of the machine tools are made in the eastern half of the U.S. today. The West Coast, though, is making more and more machine tools all the time. The states of Wisconsin, Illinois, Indiana, Ohio, Michigan, Kentucky, Tennessee, Alabama, and Mississippi make two-thirds of all machine tools.

Machine Tools in Manufacturing

Machine tools have taken a great deal of the physical work away from the man who runs the machine. It is the machine that now does the work. The most a man might have to do is to load the machine, Fig. 80-10.

Machine tools are made in many different sizes. There are many different jobs they can do. Their cost often depends on how hard or *complex* (complicated) the job is that they are supposed to do. There are more than 500 different machine tools. The number of jobs they can do is a great deal more than 500, since most machines can do several jobs with the right kind of attachments.

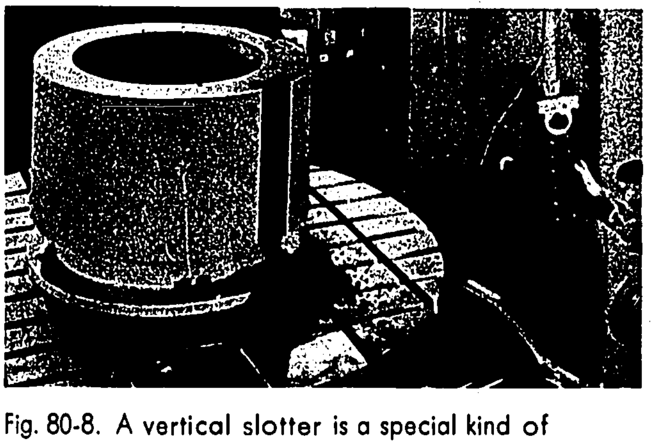


Fig. 80-8. A vertical slotter is a special kind of planing and shaping machine. This machine is shaping a part for a ship.

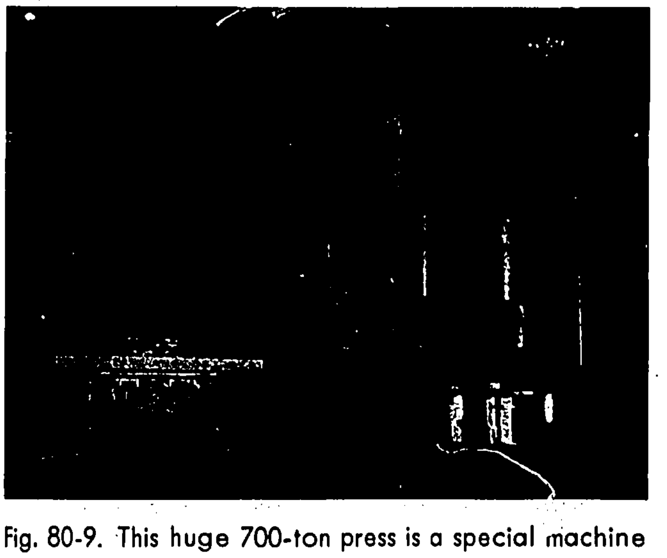


Fig. 80-9. This huge 700-ton press is a special machine tool. It is used to form automotive body components.

Precision (correctness in size and shape) has increased a great deal in manufacturing. In 1915, it was great if you could be precise to one-thousandth of an inch. Today, precision to one-millionth of an inch is common. Think how precise a machine tool must be made in order for it to make parts that are precise to one-millionth of an inch! See Fig. 80-11.

Machine tools have made progress possible in manufacturing. They have made precision and *interchangeable parts* (identical parts) possible, Fig. 80-12. They have increased savings in time and hand work. Because of machine tools, there have been more jobs in the skilled machine trades.

Machine Tools in the Future

The key to machine tools in the future is *automation* (machines run by other machines), Fig. 80-13. Machines will be run and controlled by computers. They will make more parts with greater precision in a shorter length of time. But it will always be man's mind that designs the computers and the computer programs to run other machines.

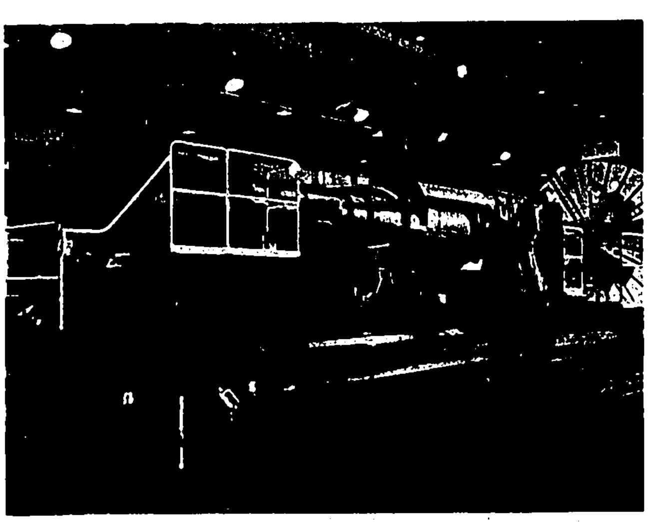


Fig. 80-10. This giant machine tool is being used to turn a part for a steam turbine. The man who runs this machine stands on the platform near the right of the picture.

Careers with Machine Tools

Machine tools hold a great future for many people. We are not only going to need people to build machine tools, but also to design and control them. There will be jobs for the graduates of high schools, technical schools, and colleges. These jobs will exist in all phases of the machine tool industry.

Fig. 80-11. This measuring machine can measure to within one ten-thousandth of an inch (.0001"). The man is looking at the built-in optical system that magnifies the part up to 100 times its real size.

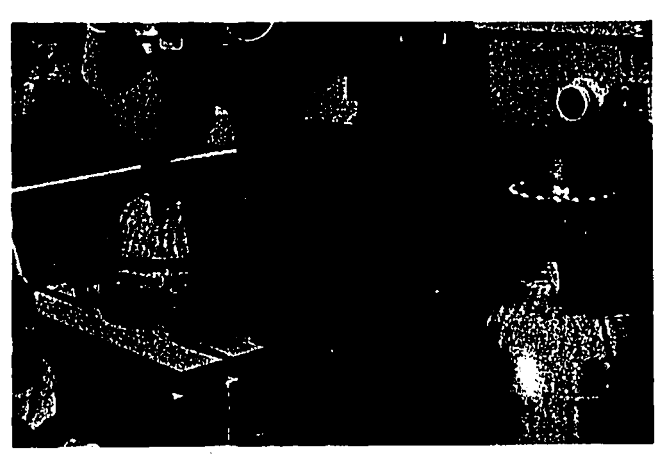


Fig. 80-12. This special milling machine is used to make identical parts. The part on the right is the original. It is being traced to produce the part on the left.

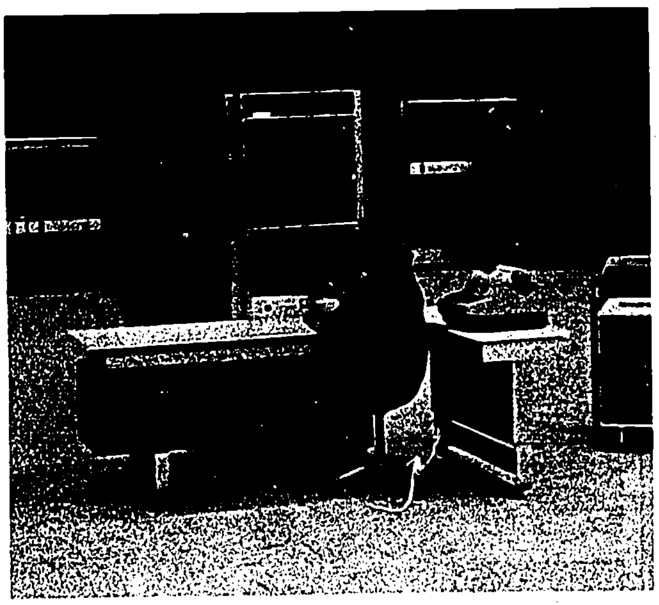


Fig. 80-13. The key to machine tools in the future will be automation. A modern manufacturing computer center will be commonplace.

Terms to Know

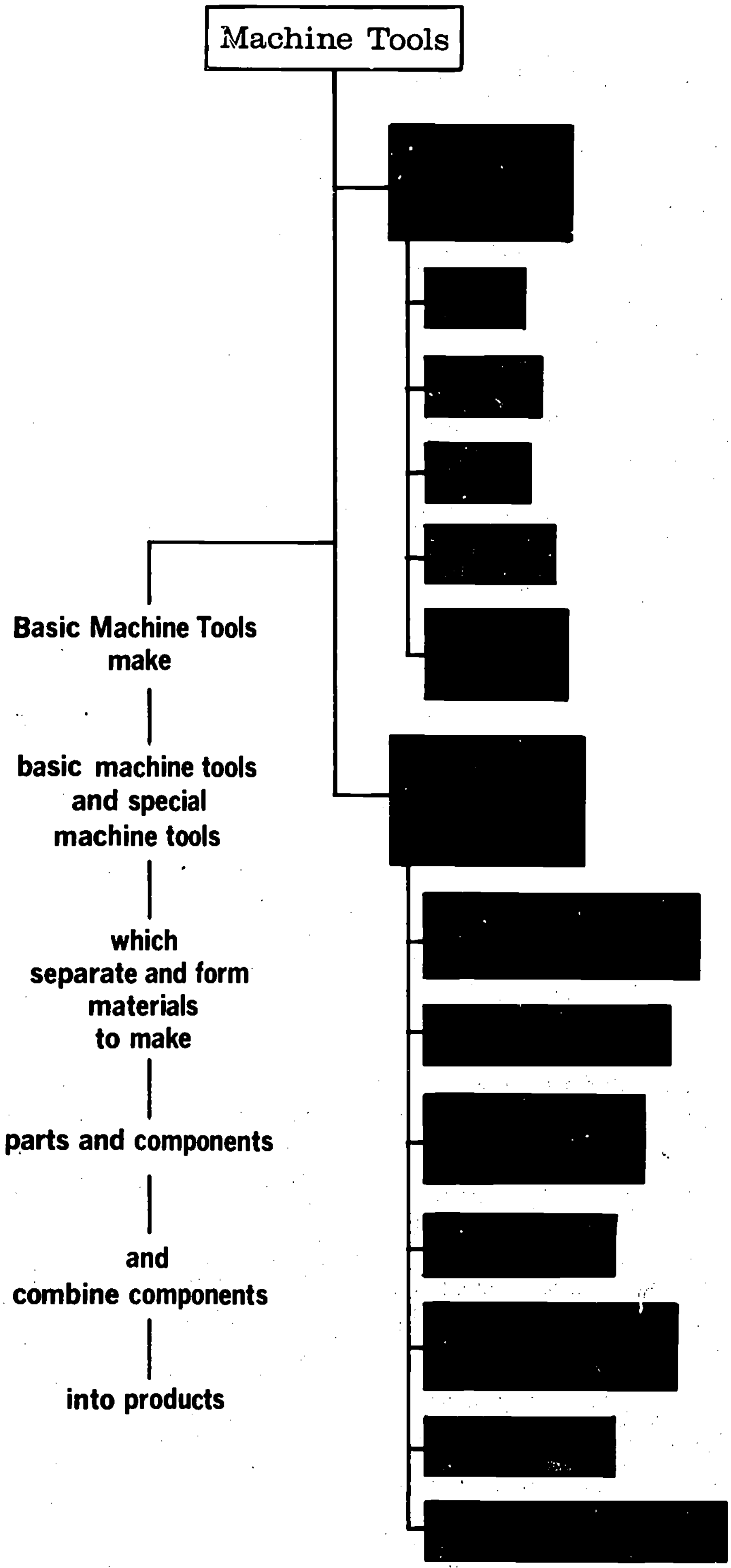
primary manufacturers
components
assemble
machine tool
abrasive
impact
pressure
basic machine tools
special machine tools
drilling
boring
turning
milling
grinding
planing
shaping
rotating
portable
reaming
tapping
hobbing
tolerance
abrading (abrasive machining)
honing
lapping
groove
slotting
extend
complex
precision
interchangeable parts
automation

Summary

Machine tools are very important to modern manufacturing. The techniques used with basic machine tools are (1) drilling or boring, (2) turning, (3) milling, (4) grinding, and (5) shaping or planing. Special machine tools add a great deal to the kinds of work that can be done by the basic machine tools.

Think About It!

1. List five parts of an automobile that were manufactured using:
   a. *basic machine tool* techniques;
   b. *special machine tool* techniques; and
   c. a *combination* of basic and special machine tool techniques.
2. Suppose you were interested in a future in the machine tool industry. What courses would you take in high school to help you prepare for the industry? What would you study beyond high school? Why?


Machine Tools
Basic Machine Tools
make
basic machine tools
and special
machine tools
which
separate and form
materials
to make
parts and components
and
combine components
into products

READING 81

Story of Rubber Products

In the last reading, you learned about basic and special machine tools. Today you will learn about rubber products. These are products that you use each day. If you rode to school today in a car or school bus, you rode on rubber tires. Tires are one of the most common everyday products made from rubber. In this reading, you will learn how many different products are made from rubber, Fig. 81-1.

A World Without Rubber

What would happen if rubber disappeared overnight? First, you might oversleep because your electric alarm clock wouldn't work right without its rubber parts. You might not have any hot water to wash with because the faucets would run all night without their rubber washers. You might try to phone the plumber, but you couldn't do this if all the rubber parts were gone from your phone.

Well, you say, the day wouldn't be lost. You could always get dressed and go to school. Problems again! Your underclothes and socks wouldn't stay up without the rubber elastic in their tops. Your shoes would feel funny without their rubber heels and soles. Look at your wash-and-wear clothes! Without the rubber used in treating the cloth they are made from, they would have to be ironed before you could put them on.

The story could go on and on. Think about the rubber products in your family car, in your school, and in the rest of your community. For instance, what would your physical education class be like without rubber soles on your gym shoes, or without rubber footballs and basketballs? Let's take a look now at how some of these rubber products are made.

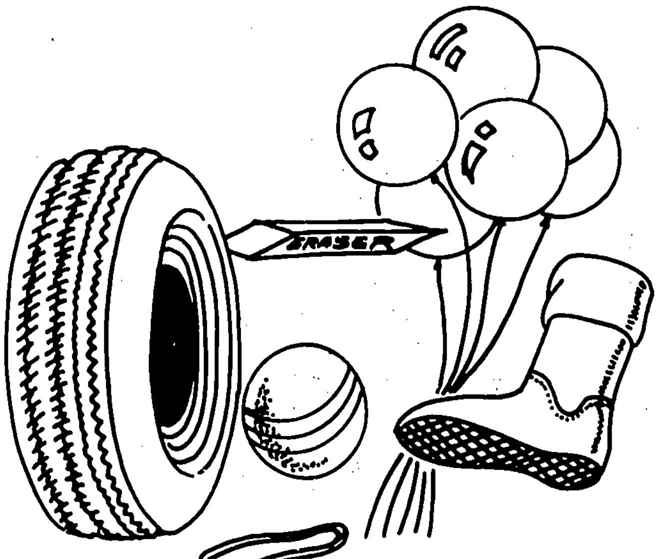


Fig. 81-1. Many products are made from rubber. Some of the more common ones are shown here.

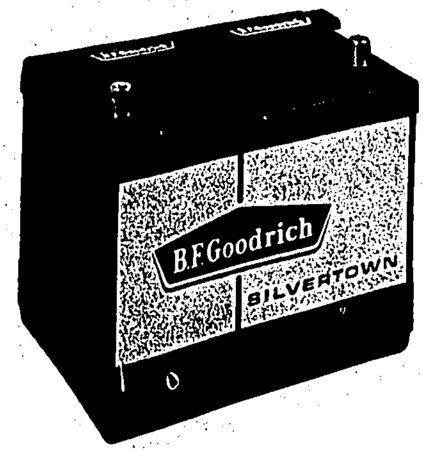


Fig. 81-2. Without rubber, you could not use the family car. This hard battery case is a molded rubber product.

Uses for Rubber

Rubber has many uses. It can be made hard enough for bowling balls and car battery cases, Fig. 81-2, or soft enough for pillows and cushions. Some rubber products like raincoats shed water, while others like sponges soak water up. Rubber can be stiff for bumper guards, or it can stretch for rubber bands, Fig. 81-3. It can keep electric current from passing through it, or it can let the current through. Rubber can be made to last for thousands of miles in tires, or it can be made to wear out in a few rubs of a pencil eraser.

The Sources of Rubber

There are two types of rubber: natural rubber and *synthetic* (man-made) rubber. Natural rubber comes from the *latex* (sap) of a tropical rubber tree. There are other plants, like Russian dandelions and milkweeds, that also contain latex. Synthetic rubber is usually made from crude oil or alcohol. Let's now take a look at the techniques used to manufacture rubber products.

Preparation of Rubber Materials

To make rubber products, it doesn't make much difference whether the rubber is natural or man-made. If the rubber is natural, it is tapped from the rubber trees and made into curds by adding acid to it. From these curds, several different kinds of crude rubber can be made. *Pale crepe* is squeezed between rollers and then hung to dry. *Ribbed smoke sheet* is dried in the smoke of a wood fire. The dried latex is then pressed into bales for shipping.

Man-made rubber is made by mixing *butadiene* (a form of crude oil), styrene, soap, and small amounts of several other materials. This mixture is stirred under *pressure* (force) and comes out as latex. Like natural latex, this man-made latex is then made into curds by adding acids to it. It is then dried and baled.

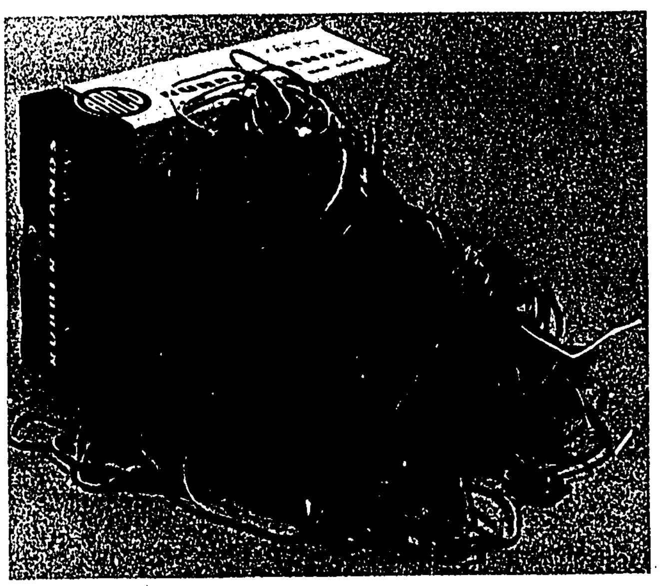


Fig. 81-3. Rubber is also used to make rubber bands. Rubber bands come in many different sizes.

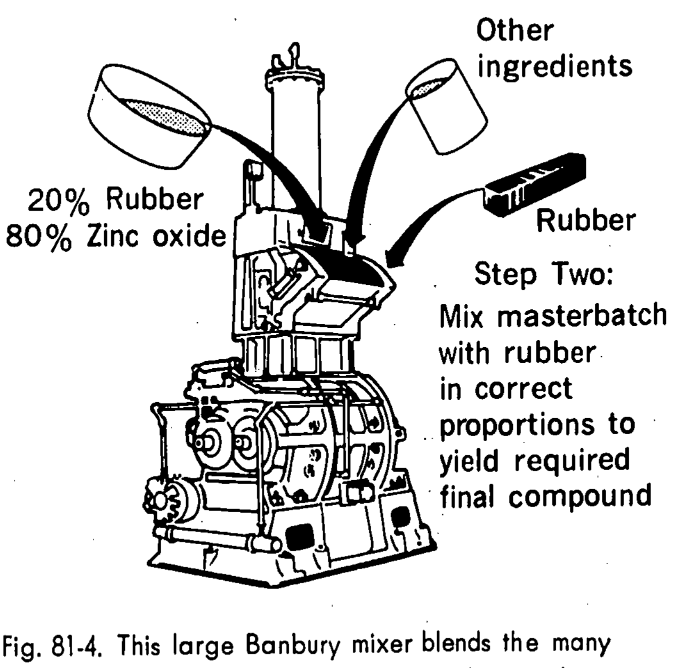


Fig. 81-4. This large Banbury mixer blends the many different rubbers and chemicals together. It makes a compound that has the right physical features for the product being made.

Making Industrial Rubber Products

In order to make rubber into standard stock forms, it must first be made into a *compound*. Most compounds are made by mixing both natural and man-made rubbers with other materials. When the baled rubber gets to the rubber plant, it is unpacked and cut up. The cut-up rubber is then heated to make it *pliable* (easy to bend and fold). The pliable rubber is then fed into a machine that grinds it into fine pieces. These fine pieces of rubber, along with carefully measured amounts of *pigment* (color), oils, and other chemicals, are then fed into a *Banbury mixer*, Fig. 81-4. In this mixer, the rubber is made into a compound that has the right physical features for the finished product being made. The Banbury mixer forms sheets of standard rubber stock. These stock sheets can then be used to make a large number of finished products. Another common standard rubber stock form would be *extended* (stretched-out) shapes, like those used to make rubber moldings, seals, or gaskets.

Making of Components or Finished Rubber Products

After the crude rubber has been made into a special type of compound, it can be made into *components* (parts) or finished products. There are five major kinds of rubber products. They are (1) *dipped products* like rubber gloves, (2) *molded products* like hot water bottles, (3) *reinforced products* like tires and boots, (4) *stamped (cut) products* like rubber aprons, and (5) *foam products* like pillows and coat linings. Many other products, like *adhesives* (glues) are classed as chemical products, not rubber products.

Dipped Products

Liquid latex, with pigments and other chemicals added, is used to make *dipped rubber products*. A mold is used to make a dipped product like rubber gloves. First, a porcelain mold is covered with a salt solution and allowed to dry. After it is dried, it is dipped into a tank of liquid latex. The liquid sticks to the mold. The longer the mold is held in the tank, the thicker the layers of latex get. When the mold is pulled out of the tank of liquid latex, it is swirled to take off any latex from the tips of the mold. After the liquid latex *sets* (dries), it is heated under pressure to harden and strengthen it. It is then stripped from the mold. Some dipped products like insulated pliers are dipped directly. The molds used are the plier handles themselves.

Molded Products

Many rubber products like hot water bottles are formed by *molding*, Fig. 81-5. In this process, the liquid latex is poured into a mold that has the shape of the finished product. The mold is then heated under pressure. The finished hot water bottle comes out of the mold hardened and ready to be used. Molded rubber products include boat bump-

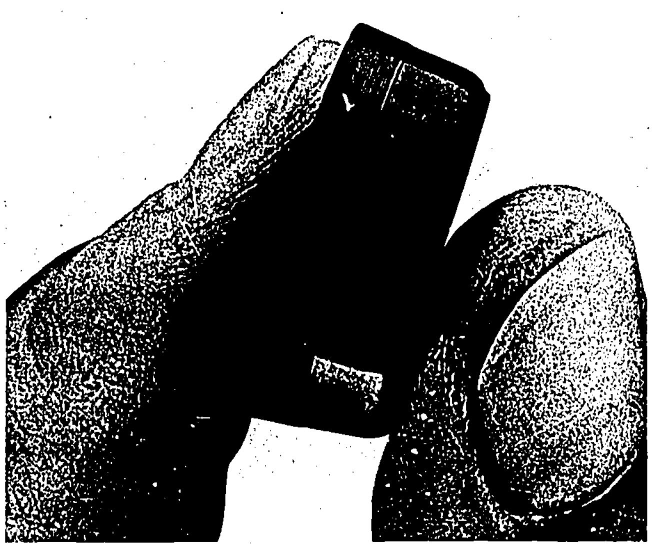


Fig. 81-5. Molded rubber products come in many different sizes and shapes.

Fig. 81-6. Tire manufacturers use a great deal of rubber. This giant tire was made to be used on earth-moving machines.

ers, battery cases (Fig. 81-2) and other parts for cars, and many different parts for subassemblies.

Reinforced Products

There are many *reinforced rubber products* that you see every day. Some of these are garden hose, friction tape, and tires for cars, trucks, and airplanes, Figs. 81-6 and 81-7. A reinforced product is made of rubber that has had some material added to it to give it shape or strength. This process is often called *laying-up*. A rubber garden hose is made this way.

First, the correct rubber compound is forced through a die (*extruded*) in the shape of a long tube. The tube is then covered with cotton cord. Then the cord-covered tube is covered with another layer of rubber. The inside of the hose is then covered with lead. The lead-covered hose is then put into a machine that hardens and strengthens it (*cures*) with high-pressure steam. After it has been cured, the lead is split off the

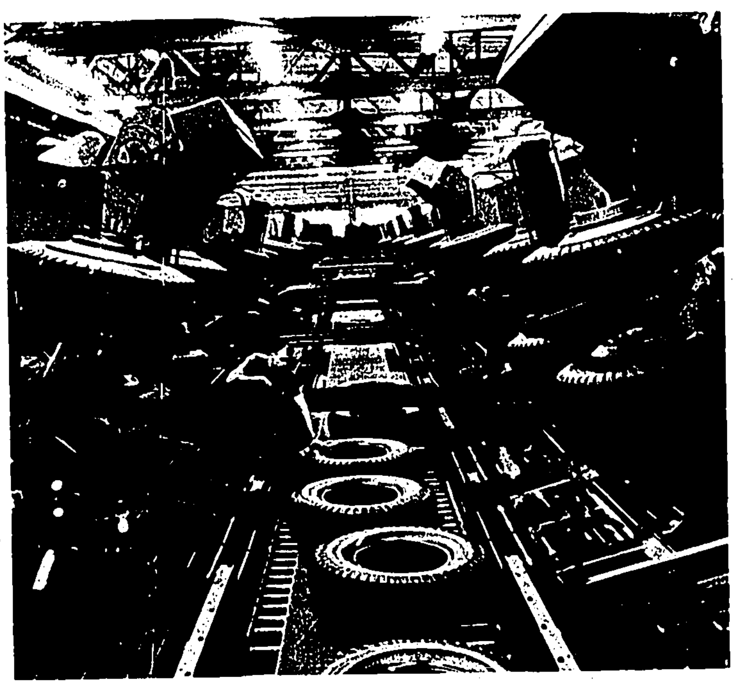


Fig. 81-7. New tires for trucks move along a conveyor between banks of molds in a tire production plant.

Fig. 81-8. One of the many reinforced rubber products is hose. Fire hose is made to withstand high pressure and wear and tear.

finished hose. Thus the lead can be melted down to use in making another hose. Some high-pressure hoses have to have several layers of cording or wire in order to make them strong enough to be used, Figs. 81-8 and 81-9.

Many reinforced rubber products use other materials that have had a thin coat of rubber put on top of them. This process of putting a thin coat or sheet of rubber on the outer layer of another material is called *calendering*. Rubber-coated *fabrics* (cloth) are the most common reinforced products made this way.

Stamped (Cut) Products

Rubber heels and soles for your shoes, Fig. 81-10, rubber washers, and rubber bands are all *stamped (cut) rubber products*. These stamped (cut) products are made from sheets, tubes, or other solid pieces of rubber. Rubber bands, for instance, are made from slices of tubing, Fig. 81-3. Rubber washers are made the same way, except that the wall of the tube may be a great deal thicker. Many rubber products are first cut and then later put into molds where they get their final finished shape. After stamped (cut) products are shaped, they are cured with heat and pressure.

Foam Products

Foam rubber products have become very common in the last several years. Foam rubber is made by mixing liquid latex with air in high-speed machines called *aerators*. The foam froth is then poured or piped straight into the molds. The molds are then taken by conveyors to a steam chest where they are hardened and strengthened.

You can buy foam rubber by the yard, by the piece, or by the pound. You can also buy it as shredded foam. Foam rubber is used to make pillows, seat cushions, carpet padding,

Fig. 81-9. Another reinforced rubber product is the hose used to put gasoline into your car. This hose must withstand the chemical action of the gasoline.

Fig. 81-10. In the near future, more shoes will be stamped (cut) from rubber. This worker's responsibility is to inspect, then stack the die-cut soles before shipment to shoe manufacturers across the country.

Fig. 81-11, and many other products where the customer wants softness and comfort.

Rubber Today and in the Future

In the U. S. today, on the average, more than 26 pounds of rubber are used each year by every man, woman, and child. This is not true outside the U. S. In the rest of the world, each person uses less than three pounds of rubber each year. By 1975, the number of rubber products in the U. S. is expected to increase by 64 percent compared to 1968 standards.

Summary

Rubber plays an important part in our lives. Rubber can be natural or man-made. Many of our rubber products have been dipped, molded, reinforced, stamped (cut), or foamed. The importance of rubber is growing each day. Both natural and man-made rubber work well in the manufacture of major rubber products, as well as in the manufacture of smaller parts that are used as parts for larger products.

Fig. 81-11. Foam rubber is molded into carpet padding. A padded carpet lasts longer, and it is soft and comfortable to walk on.

Terms to Know

synthetic	reinforced rubber products
latex	stamped (cut) rubber products
pale crepe	foam rubber products
ribbed smoke sheet	adhesives
butadiene	sets
pressure	molding
compound	laying-up
pliable	extruded
pigment	cures
Banbury mixer	calendering
extended	fabrics
components	aerators
dipped rubber products	
molded rubber products	

Think About It!

1. You use many products every day. List all the products you have used today that are made of rubber or that contain rubber parts.
2. Figure 81-10 in this reading says that more shoes will be made from rubber in the near future than are now made from rubber or rubber parts. What other products or *components* are made of materials that will be replaced by rubber or rubber parts?

The Story of Rubber Products

[redacted] — [redacted] — [redacted]

[redacted]

[redacted]

[redacted]

- Dipping
- Molding
- Reinforcing
- Stamping or cutting
- Foam processing

READING 82

Story of the Telephone

When most people think of the telephone, they think of the familiar instrument that sits on a desk at the office or on a table at home. Your home or office phone is really just the first chapter in the story of the telephone.

Your home or office phone is somewhat like an iceberg. Most (91%) of the iceberg is under water where it can't be seen. Like the topmost part of the iceberg, your phone is just a small part, though a very visible one, of a huge telephone network. Most of the machines that make up this network are hardly ever seen by the public.

The Telephone Network

By itself, your home or office phone is useless. If its wires were cut, it would be just a big paperweight. When it is connected to the telephone network, it becomes one of your most important and useful tools. You can use your phone to reach a great number of other phones in this country. You never see most of the network that runs the part you do see, but like the rest of the iceberg, it is there.

Your home or office phone set is connected by wires to a phone company *central office*, Fig. 82-1. This central office is in turn connected by *trunk lines* to other central offices and to long-distance centers called *toll offices*, Fig. 82-2.

A telephone network is made up of three major kinds of equipment. They are (1) *stations*, (2) *connecting circuits*, and (3) *switching centers*, Fig. 82-3. A *station* may be a telephone set or perhaps some other device like a teletypewriter or a data set. These stations are connected by *circuits* (paths that electric currents follow) to *switching centers*. There, computer-like machines figure out the exact route that a

Fig. 82-1. This is what the inside of a central office looks like. There are long aisles lined with frames of switching equipment.

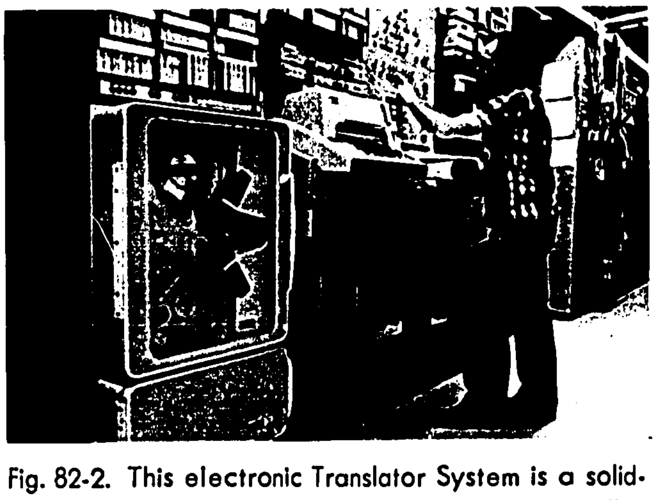


Fig. 82-2. This electronic Translator System is a solid-state system that is electronically controlled. It is used to control the switching systems in some of the toll offices.

phone call must take. Then they set up the connections that link each station along the route. Central and toll offices are switching centers. The connecting circuits may include wire or cable, coaxial cable, short wave radio, microwave relay stations (Fig. 82-4), cables that cross under oceans, and communications satellites in the sky.

The stations, switching centers, and connecting circuits must all work together smoothly if you are to complete a phone call. All of this equipment (literally billions upon billions of separate parts) is linked together through a single nationwide network. This network could be thought of as one big machine, or as a giant computer: the world's biggest computer! Its job is to pass *data* (information) between millions of separate stations. These data can take many different forms: voice, visual, written, or drawn data. In your home or office, you can take command of this computer by just spinning a telephone dial. This giant computer is simple and easy to use.

The story of the telephone is the story of this big machine and the industry that designs, builds, and runs it. The telephone industry is made up of the Bell System and its companies, and about 2,000 independent phone companies.

The whole telephone industry employs slightly more than one percent of the total work force in this country. More than half of its workers are women, Figs. 82-5 and

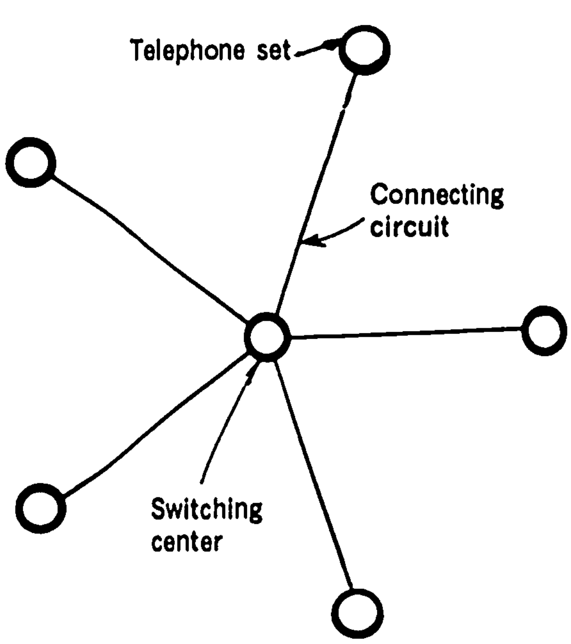


Fig. 82-3. All telephone networks are made up of three types of equipment: the stations (telephone sets), the connecting circuits, and the switching centers.

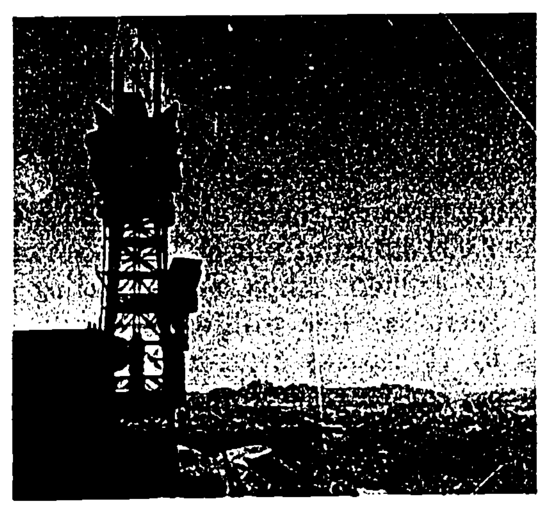


Fig. 82-4. Microwave radio relay towers, like this remote station in the Southwest, move phone calls from station to station as line-of-sight radio transmissions.

Fig. 82-5. Here you see a long-distance operator at work. As machines took over the physical job of switching phone calls, operators could spend more of their time helping telephone customers.

82-6. Of course, only a small part of the whole industry works in the direct manufacture of phone parts and network equipment, Fig. 82-7. In 1967, the independent phone companies employed more than 100,000 workers. The Bell System itself employed more than 840,000 workers. In that year, only the federal government employed more people than the phone companies.

All of these companies, Bell and non-Bell, are linked up through the Bell System's nationwide switching network. Thus you can make a call from your phone to any other phone in this country without even knowing that your call is going through the lines of other phone companies.

In this network there are switching centers in 8,000 different places. There are more than 700 million miles of connecting circuits. There are five million billion (5 followed by 15 zeroes) possible different stations that can be linked up in this network.

R & D Yields New Products

In 1948, Bell Labs set up a small-scale customer trial of push-button phones. Users liked them, but these phones could not be mass-produced because of their size and cost. The use of the *transistor* invented by Bell Labs cut down both the cost and the size of the push-button phone, Fig. 82-8.

Fig. 82-7. Telephone company workers install and repair equipment in the customer's home or office. In this picture, the worker is installing a wall telephone.

Fig. 82-6. This telephone operator is giving a customer "directory assistance" (information). This is one of the many workers in the Bell System. Notice that she is using a list of emergency numbers and numbers that are often called.

Fig. 82-8. This is a close-up of the standard 12-button Touch-tone® telephone set. The * and # buttons are not yet being used, but they will be needed for new services that will come into use with ESS.

The Touch-Tone® telephone uses a different and faster form of signaling than the dial phone. It also sends the *digits* (numbers) into a central office much faster. It would cost too much to replace all the central office equipment now being used. Thus a *receiver-converter* is needed to turn the Touch-Tone® signals into a form that can be used by central office equipment.

Human-factors engineers had to find out how to make it easy for people to use the push-button phones. They had to find out such things as the best arrangement for the buttons, their size and shape, and the force needed to make them work. Their designs were then turned into prototypes in the Telephone Model Shop at Western Electric's Indianapolis plant.

As these changes were being made, customer trials were set up in two towns. There, Touch-Tone® phones were offered in many different styles and colors. These trials were successful, and so the new phone went into full-scale production.

The engineers at Western Electric and the Bell Labs worked closely together on this project. They kept each other informed of design progress and manufacturing needs and problems. This cut down on the time between the choice of the final design and the shipment of the finished products to the phone companies.

Production of Equipment

It would take far too long to describe each step of the production of the Touch-Tone® phone and the equipment needed to make it work. "On-line" and automated machines are used a great deal at Western Electric's Indianapolis plant where the phone parts are made. Most of the parts used in assembling the phones are made right at the plant by such mass-production techniques as die casting, stamping, and injection molding, Fig. 82-9. Power tools are used a great deal in assembly. Parts, subassemblies, and the finished products are all tested for quality control, Fig. 82-10.

Western Electric uses nearly every known production technique, including several that are unique to or were first used in tele-

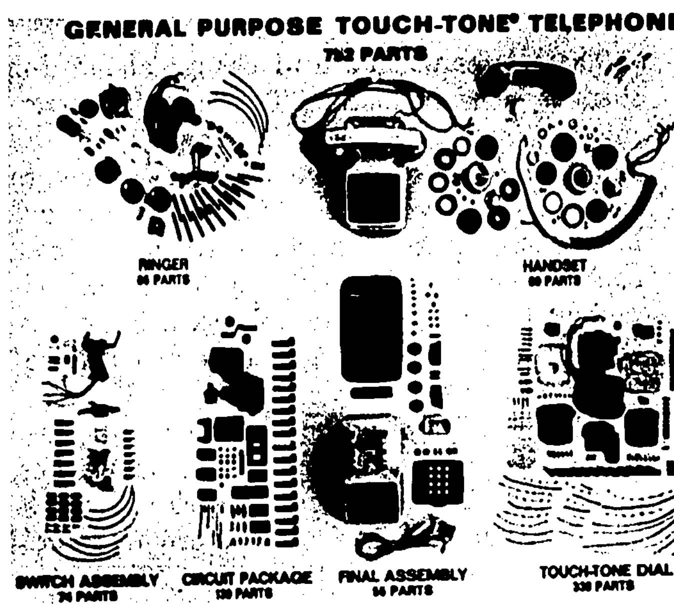


Fig. 82-9. This shows the 752 separate parts of the Touch-Tone® telephone grouped together into the major subassemblies.

Fig. 82-10. This is the final inspection of a completely assembled Touch-Tone® Trimline telephone. Parts and subassemblies of each telephone are also tested for quality control at each step of the manufacturing process.

phone manufacture, Fig. 82-11. Of the more than 100 known chemical elements, all but seven are used in some stage of manufacture or research at Western Electric.

The Telephone Industry of Tomorrow

There is challenge and change ahead for the telephone industry. The need for sending and receiving data is growing all the time. More people are using machines to send and receive data. More machines are being used to send and receive data from each other. Computers can be linked together through the telephone network so that they can exchange huge amounts of data at very high speeds.

The use of *computer time-sharing* is also increasing. Many small colleges, businesses, and research labs need modern computer services, but very few can afford to install a costly computer of their own. What they usually do, then, is to agree to take turns using one central computer. They share the cost according to the amount of time they use. This is called *computer time-sharing.* Each user has a teletypewriter, data set, or some other station set that is linked to the central computer through the telephone network.

Electronic Switching Systems (ESS) are already at work in some Bell System central offices. These systems use solid-state circuits and stored program control, Fig. 82-12. Stored program control makes it possible for ESS to grow and change. When new services are offered by an electronic central office of the future, the only thing that will have to be changed will be its program. Its equipment will not have to be rewired, as it must be in the present central office when new services are set up.

ESS will not replace the present switching systems overnight. It will probably take several decades to complete the changeover. The present systems will only be replaced as they reach the end of their usefulness. This kind of gradual growth and change has been typical of the telephone industry in the past 100 years.

The pace of research in the industry is also growing rapidly. Such new developments as the integrated circuit and videophone hold great promise for the telephone

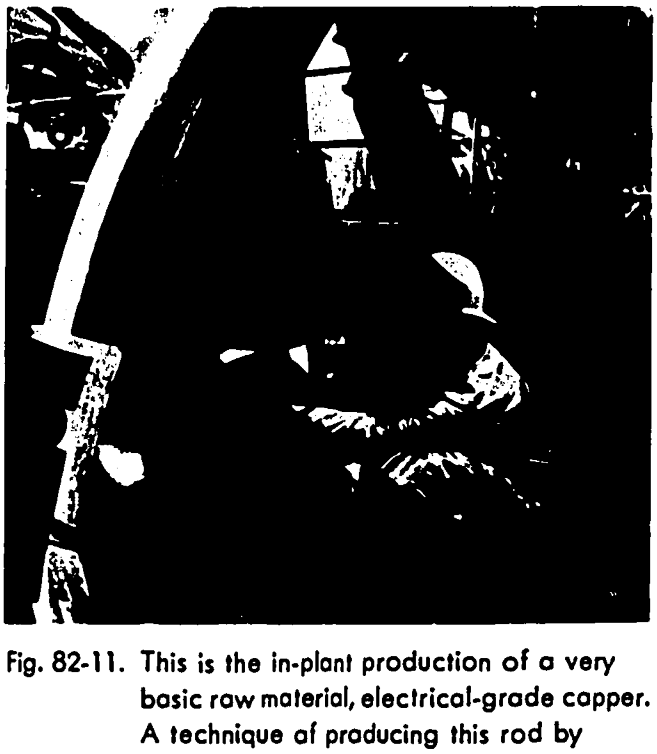


Fig. 82-11. This is the in-plant production of a very basic raw material, electrical-grade copper. A technique of producing this rod by continuous casting, rather than in batches, has been developed.

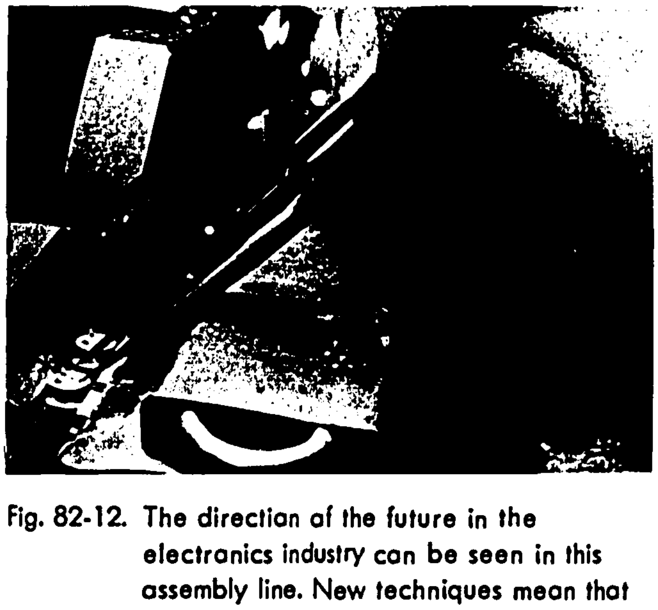


Fig. 82-12. The direction of the future in the electronics industry can be seen in this assembly line. New techniques mean that new material handling and processing techniques will be needed.

industry of the future, Fig. 82-13. Researchers are already exploring the possible use of the laser in telephone manufacture, Fig. 82-14.

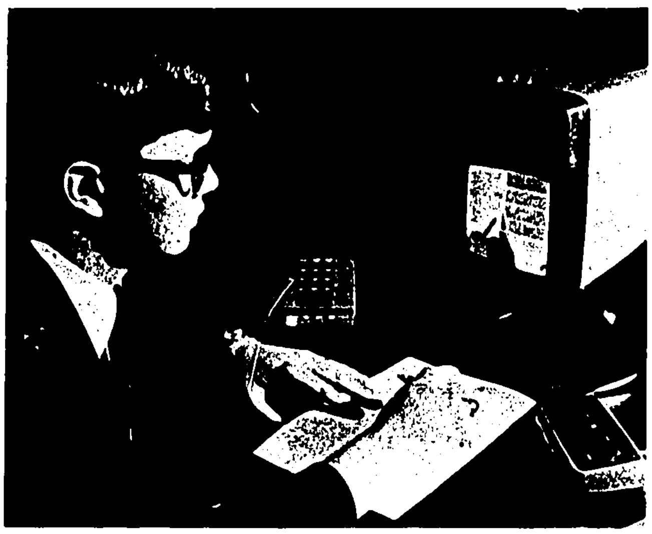


Fig. 82-13. This is a Picture-Phone®. This phone is still being tested in research experiments.

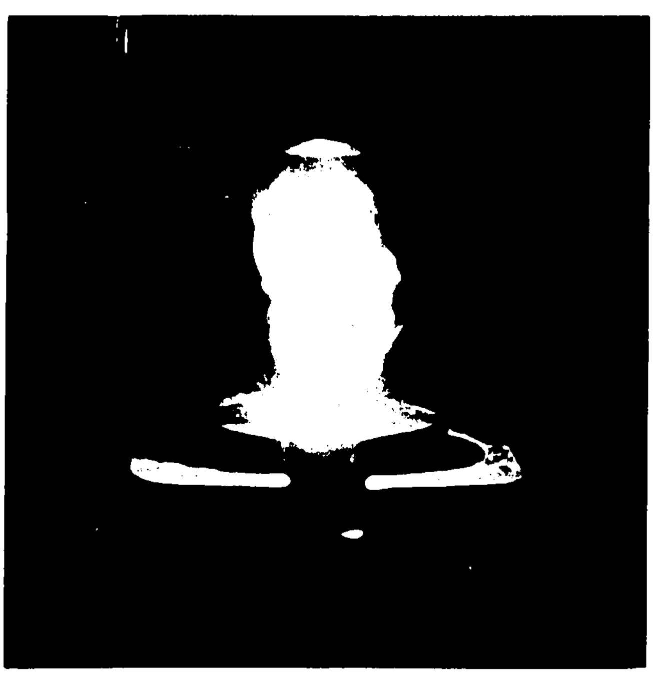


Fig. 82-14. This is one of the earliest uses for the laser in telephone manufacture. The laser is being used to pierce a hole in the diamond die used for drawing fine wire.

Summary

A telephone network is made up of three types of equipment. These are (1) stations, (2) circuits, and (3) switching centers. Each piece of equipment must work smoothly with every other piece for people to be able to use this network. This whole network can be thought of as one big machine, or as a giant computer.

Slightly more than one percent of the total work force in this country works in the telephone industry. This industry is made up of the Bell System and about 2,000 independent phone companies. All these companies, Bell and non-Bell, are linked together through the Bell System's nationwide switching network. This network can send and receive data in many different forms: voice, visual, written, and drawn data.

Research in the telephone industry has changed and improved the phone and its network of equipment. It will continue to do so in the future.

Nearly every known production technique is used in the manufacture of phones and their equipment. These techniques range from the very simple to the very complicated.

There is challenge and change ahead for the telephone industry. More and more it will be used as a system for sending and receiving data between people and machines and between machines and other machines.

Terms to Know

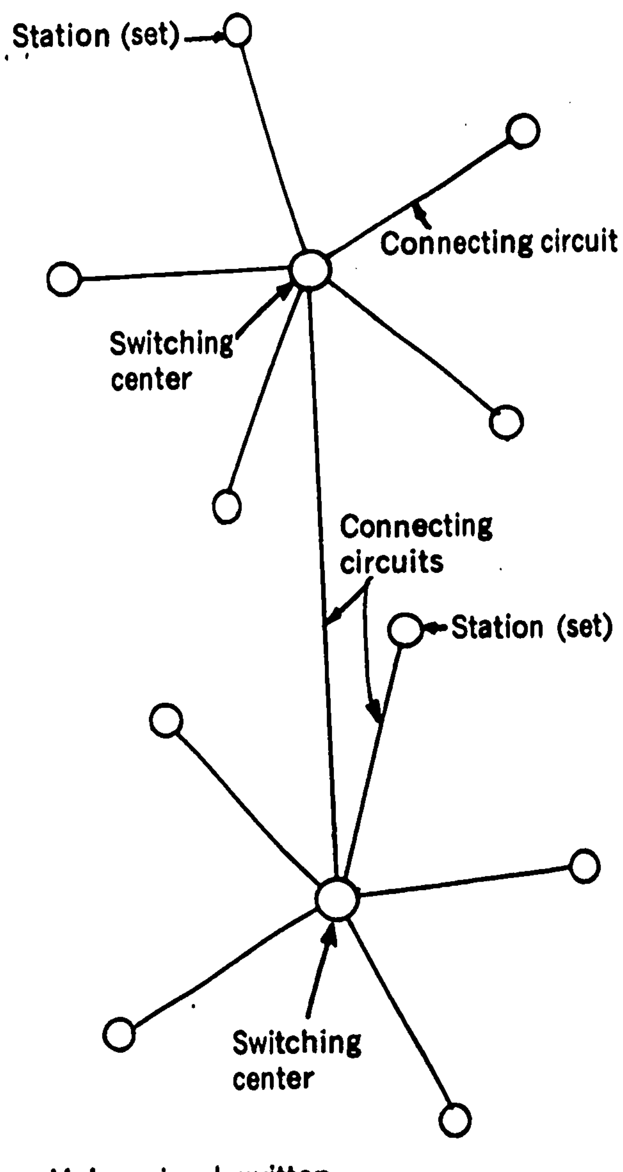
central office
trunk lines
toll offices
stations
connecting circuits
switching centers
data
transistor
digits
receiver-converter
human-factors engineers
computer time-sharing
electronic switching systems (ESS) circuits

Think About It!

1. What is the name of your local telephone company? Is it an associated company of the Bell System? Is it an independent company?

2. This reading states that there is challenge and change ahead for the telephone industry. What are some of these challenges? What will the resulting changes be?

The Telephone Network



Voice, visual, written, and drawn data are sent and received.

Ind